A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(2:00 p.m.)

CHAIRMAN KRESS: Okay. It's time that we went back into the section again.

And the standard request is that you'll have to identify yourself and tell us why you're qualified to talk to this --

DR. FORSBERG: August body, right?

CHAIRMAN KRESS: Right. So with that I'll turn it over to Charles and I'm looking forward to this talk.

No, no, we're not recusable on this one.

So you might want to introduce yourself, Charles.

DR. FORSBERG: I am Charles Forsberg from Oak Ridge National Laboratory. I guess I've been involved in every type of fuel cycle you can imagine, plus some reactor designs, and I'd like to discuss some alternative reactors and fuel issues and future nuclear power issues.

I think the workshop here is quite appropriate because we're looking at the long term issues of nuclear power, nuclear power options for 20 to 30 years.

But if you look out 20 or 30 years you

have to ask some more fundamental questions. The first fundamental question is: what are you going to use the energy produced from a nuclear power reactor for?

There's an implicit assumption most of the time, and that is that electricity is the primary product, the primary final product of a nuclear power plant. That assumption is, of course, historically true.

But if you look out to the future 20 or 30 years, there may be other uses of nuclear power that may also be as significant as the existing nuclear power industry in the United States.

It's this particular subject I would like to address. In particular, I'd like to address the advanced high temperature reactor for hydrogen and electricity production.

This is a joint effort of Oak Ridge National Laboratory and Sandia. I should emphasize here that when we talk about the use of a reactor for multiple purposes, for example, hydrogen and electricity, it changes the technology and it may change the regulatory structure.

The production of hydrogen requires -- has some very special technical requirements, and those

technical requirements may also impose some very unusual regulatory issues.

So I'd like to address both issues, the issues of hydrogen production and use the requirements needed for hydrogen production to define a reactor concept, which leads to some of the regulatory issues.

Could I have the next slide?

I'd like to discuss four subjects -- three subjects: is a nuclear based hydrogen economy in our future?

Second, an advanced high temperature gas -- high temperature reactor for hydrogen production or electrical production.

And third, regulatory implications.

May I have the next slide?

I start with a question: is a hydrogen economy in our future?

And I put in parenthesis something I think that many people may not recognize, and that is it may already be here. In fact, I'm going to talk about hydrogen economy with -- hydrogen economy without talking about hydrogen fueled vehicles. I'm not going to talk about distributed hydrogen. I'm going to spend one slide on that.

Rather, I'm going to talk about old

fashioned hydrogen consumption, the old fashioned economy that uses a great deal of hydrogen.

Could I have the next slide.

We're seeing rapid growth as expected in industrial demand. Currently the production uses -- growth of hydrogen production uses about five percent of the natural gas in the United States, plus a large quantity of refinery byproducts. It's a big energy user.

If the projected rapid growth of hydrogen consumption continues, the energy value of the fuel used to produce hydrogen will exceed the energy output of all nuclear plants by about 2010, and continue to expand at a very rapid rate like ten percent per year thereafter.

There are two users, one which I suspect will be rather static over the next couple of decades. That's the chemical industry, to bake ammonia and methanol. It's a large consumer today, but it's probably not a rapid growth market.

The rapid growth market and the driver for hydrogen consumption in the U.S. is the changing refinery conditions that are driving up the hydrogen demand. I'm going to go into this in more detail, but there are basically three things that are happening.

The oil supply is changing. We're beginning to use more heavy crude oils, fewer light crude oils.

Second, there's a demand for cleaner fuel.

And third, there's a changing product demand.

Thirty years ago, the primary use of crude oil was to refine it into home heating oil. These days, of course, it's gasoline.

Last, if non-fossil sources of hydrogen are used, lower value refinery streams can be used to make gasoline rather than hydrogen, and thus reduce oil imports.

Could I have the next slide?

I want you to spend some time on this slide to explain what's happening in the refinery industry and why increasing use of more abundant crude oils reduces refinery yields, unless non-fossil hydrogen is used.

This is where we were, let's say, 30 years ago. We primarily used light crude -- light, sweet crude oils. These crude oils you could put into an old Chevy engine, turn on the ignition, and it would start. It would work. Didn't even need a refinery. Had a little bit of refining, produced the nice, dirty

fuel, but it worked.

Things are changing in two ways, in two dimensions. The first, we're going from light, sweet crude oil to heavy, sour crude oil, like Venezuelan crude. Venezuelan crude's about six percent sulfur. If I put Venezuelan crude in one of these cups, I could turn it over after -- if it was at room temperature, and come back in a half hour, probably before it would stain this table. It's thicker than molasses.

Needless to say, this does not work well in a car, and thus, it takes a tremendous amount of refining to make a clean fuel.

So we're in a transition from the upper left to the lower right. That's what's driving the hydrogen demand in the U.S.

The very light crudes have a hydrogen to carbon ratio of about two to one, which is about what gasoline is, two hydrogens per one. The heavy sour crudes from Venezuela have a hydrogen to carbon ratio as low as 0.8 to one. To make gasoline you've got to get over to two to one.

So there's a tremendous hydrogen input if you take a sour crude and go this direction.

At the same time people have decided to

take sulfur out of crude oil. They don't like sulfur in their tailpipe. They've also decided they prefer to have a gasoline supply that is relatively nontoxic, that is, we're removing things like benzene from the gasoline supplies of the United States. And the consequence of that is more and more hydrogen consumption.

DR. POWERS: It even goes beyond that because by taking out the aeromatics you reduce the octane level -- octane rating of it, and so now you have to do more processing on the octanes.

DR. FORSBERG: Yes.

This type of refinery has about 95 percent efficiency. That is for every 100 BTUs going in here you get 95. This type of refinery for every 100 BTUs you get about 80 BTUs out. So the refinery efficiency is dropping.

Now, what's happened is that 30 years ago, 40 years ago refineries actually made excess hydrogen. It was flared, surplus product. Thirty years ago, they were hydrogen neutral. These days they're hydrogen hogs, and they make their hydrogen by taking some bottoms of the crude and putting it into a hydrogen plant to make more hydrogen, and they also consume very large quantities of natural gas that goes

into making gasoline.

The bad news, of course, as you've probably heard, is natural gas prices are up. They've doubled, some cases tripled in the last couple of years. We now have a situation where natural gas -- where the gasoline prices are coupled to natural gas prices, as well as oil prices.

This is something we have not previously seen in our history, different kind of economics, different kinds of issues.

A five dollar per million BTU natural gas makes expensive electricity. Five dollar per million BTU natural gas is going to make very expensive hydrogen, and thus, there's a potential of a very large market if you can find economic methods to produce hydrogen for the refinery industry.

There's also a danger that if you don't find methods to produce economic hydrogen, what you're going to do is drive much of this industry offshore to areas that have low priced natural gas. So what we have is a changing -- changing environment in terms of crude oil, a changing environment in terms of the product, and that in short is what's driving the hydrogen demand and causing the very rapid increase.

The question is can we find another source

of hydrogen, that is, a non-fossil fuel source of hydrogen?

And today I'd like to discuss the possibility of using nuclear power or nuclear energy as that source of hydrogen.

Could I have the next slide?

There are potential multiple economic benefits for non-fossil sources of hydrogen. There are four of them, and they're independent of how you make the hydrogen: increased transportation fuel yield per barrel of oil. The lower value oil components are converted to transport fuel rather than hydrogen.

That would save you perhaps ten, 15 percent on oil imports, and of course, that would reduce oil imports and also reduce natural gas.

Second, if you have cheaper hydrogen, one can make greater use of heavy crude oils. They're far more abundant than light crude oils, and more importantly, most of the heavy crudes are in the Western hemisphere, happen to be what we have, what the Venezuelans have, and what the Canadians have.

In the United States it turns out our worst crudes are in California, by convenience.

(Laughter.)

DR. FORSBERG: Third, competitive chemical industry. There's a real concern in the chemical industry that if those high natural gas prices continue, we're going to drive much of the chemical industry offshore.

And last, of course, you have much lower carbon dioxide emissions.

In short, what's happened is the chemical industry is having a changing world.

Now, I thought I should put in one slide about the hydrogen economy because if you pick up all of the popular newspapers and magazines, what they always talk about is the hydrogen economy, and what they mean by the word "hydrogen economy" usually is as liquid hydrogen or pressurized hydrogen is a transport fuel, and distributive power.

I won't make any claims whether or not they hydrogen economy will fly. Don't know. What I do know is if you're ever going to get here, you better have a very large infrastructure today to get to a hydrogen economy because otherwise you'll never get the economics of scale, and making this transition would be extremely difficult.

So the development of non-fossil hydrogen is important, both for the refinery and chemical

demand, but it's also very important if you want the option of a hydrogen economy, because a cold start of a hydrogen economy would be an extraordinarily difficult thing to do if you had to bring up large hydrogen production facilities with economics of scale at the same time while you're developing the uses for it.

I'll start at the nuclear side of the issues here. Hydrogen can be made from -- hydrogen can be produced with heat from a nuclear reactor. Basically heat and water equals hydrogen and oxygen. Nuclear energy would compete with natural gas for hydrogen production.

Natural gas is a primary way we make hydrogen. We do have very high natural gas prices right now, about five dollars. There are a couple of things that are, of course, very nice about nuclear. In terms of refinery demand, the hydrogen demand is almost constant, which means you have a constant hydrogen demand, which would, of course, better match a nuclear low.

Well, that's the good news. The bad news is it's not easy to make hydrogen from water. There are processes with projected efficiencies greater than 50 percent. However, big point to be made here: high

temperature heat is required, 800 to 1,000 degrees C. If you're going to make hydrogen from nuclear power, it's going to take a very special machine to do so.

Existing commercial reactors cannot produce heat at these high temperatures. You have to have an alternative reactor concept or concepts.

I'm going to -- the next slide I will show you one example of a hydrogen cycle. This is a chemical process to convert high temperature heat and water to hydrogen and oxygen.

About 1,400 cycles have been invented. People have examined them. The competing -- most of the competing cycles are called sulfur cycles. This one currently is the leading contender, the one that's receiving most of the research in Japan, which has a moderate sized program in this area.

It's called the iodine-sulfur process. we start with heat at 800 to 1,000 C. We produce oxygen and hydrogen with, of course, the input of water. The key chemical step that couples with the nuclear reactor is the decomposition of sulfuric acid into water, sulfur dioxide and oxygen at 800 to 1,000 C.

The oxygen, of course, is a byproduct, or a waste product. The sulfur dioxide is circular -- cycled around, mixed with water and iodine to form

hydrogen iodine and sulfuric acid. The sulfuric acid goes back through this cycle. They hydrogen iodine goes through a second cycle that ultimately yields hydrogen gas and iodine. So you have two sets of chemical reactions in the reactor.

The key thing about all of these cycles that the people have looked at that look reasonably practical is there's this 800 to 1,000 degrees Celsius temperature, and they're coupled to some complex chemistry and some fairly aggressive chemistry, such as the decomposition of sulfuric acid.

I mentioned that because what it means is this is your interface, and you have this chemical plant on this side and your nuclear plant on this side. This chemical plant for, let's say, a 600 megawatt reactor would be producing about 100 million cubic feet of hydrogen a day.

You know, there are going to be a few 1,000 or tens of thousands of tons of reagents in these systems. And if you think of a couple of thousand tons of sulfuric dioxide or a couple of thousand tons of iodine, you recognize there's some non-trivial hazard issues associated with the right side of the plant.

In fact, you might have a debate on

whether or not your primary safety concern is the left side or the right side. It's not intrinsically obvious to me that you can make a blanket statement that safety problems are on the nuclear side if you're into this kind of game.

I would now like to describe one reactor concept that we have been examining that might meet these requirements, and they're very special requirements. That's an advanced high temperature reactor, a reactor concept for hydrogen production.

The main point, however, I want to emphasize with this example is not only describing the example, but emphasize that different products may require different reactors.

If somebody proposes a new product from a nuclear reactor, it may very likely imply you have to think about how you're going to design the reactor, and it may be fundamentally different than anything you've built before.

We've been thinking electricity, electricity, electricity. That imposes one set of requirements on the reactor, one set of requirements on the regulator, one set of requirements on the operator.

If you change the product, you may need to

change the reactor, the regulatory structure, and how the operator thinks about things. That's a very important message I'd like to leave with you today, that there really are some large changes if you think about changing products.

We've only begun to examine this issue. I'm sure it's not an issue that's received much examination anywhere else, but it's important to recognize, you can't apply old rules if you change the product. Some things are easier; some things are more difficult.

Could I have the next picture or the next slide?

There's a very simple description cartoon of this concept. What we're proposing in this case is a graphite reactor, similar to a MHTGR with graphite fuel. The molten salt goes up in the molten salt coolant. We're using as an example a lithium fluoride, beryllium fluoride salt, although there are several other salts that are potential candidates.

The heat is transferred in the heat exchanger to the chemical plant and the molten salt goes back to the reactor, but the basic reactor core would be similar to an MHTGR modular high temperature gas filled reactor, except that the coolant is a

molten salt.

Heat would be transferred in a special heat transfer device to the chemical plant. It takes water in, produces hydrogen and oxygen.

Important point to be noted about this interface. High temperature, but it's also a chemical plant. Inside this side of the heat exchanger we're talking about the catalytic decomposition of sulfuric acid.

So this has a solid catalyst bed in tubes, has a variety of other design features that can impact the design of the nuclear side of the plant. This is not a water interface or a helium interface or a gas turbine interface. It's a chemical plant interface, with all the constraints and issues that you have to address in operating a chemical reactor.

And that of course includes the regulatory issues of that interface. There are some very serious regulatory issues that you don't normally think about.

Could I have the next slide?

Let's think about what we might want if we're going to make a high temperature reactor. What's -- what are our requirements? What would we prefer to have, especially if we're going to have one that is blazingly hot?

Well, the first requirement is we really want low pressure operation. We want low pressure operation for a couple of reasons. First, medals become weaker at higher temperatures. If we're going to higher temperatures we'd rather avoid the situation of high temperatures and high pressures. That's a double difficulty.

And at 1000 C., strength of materials becomes and endurance of materials becomes a major issue. So we need the low pressures to minimize strength.

We also would like to match the chemical plant pressures. The chemical plant pressures in this system will be near atmospheric.

We would rather not have a high pressure primary system feeding to a low pressure chemical plant because in that case we have to worry about what happens if you have a leak in the high pressure nuclear system and it pressurizes a low pressure chemical plant with a high inventory of hazardous materials.

So we have to worry about the nuclear plant doing bad things to the chemical plant, and as I say, that's not a trivial detail if you have thousands of tons of nasty materials. So this is a

situation where the nuclear plant could be a threat to the chemical plant or vice versa, and you have to think about both and design to avoid those issues.

It's a different mindset. We think about a particular nuclear plant. In this case we've got to protect both plants.

Second, we want very efficient heat transfer. We need to minimize the temperature drops between the nuclear fuel and the application to deliver the highest possible temperatures, and for that reason we have chosen a liquid coolant.

Can I have the next slide?

I'm showing here a picture of the Japanese high temperature engineering test reactor fuel that's designed for 950 C. helium exit temperature. This reactor is currently operating. It's in its first year of operation. They are not yet to 950 C. If I remember right, they are somewhere around 850 C., and after a couple of years they're going to run the temperature up to 950 C.

And it's a coated particle fuel like the fuel we would use. It's slightly different type of fuel element because they run into much higher temperatures.

Now, the reason I point this out is

they're running at 950 C. We'd like to run 1000 C, maybe a little warmer than that, but this is 950 C in helium. And if you use a much better heat transfer material, like a molten salt, you reduce the temperature -- the temperature drops the required to transfer heat inside the fuel element, and thus a 950 C. exit temperature for helium is probably substantially over 1000 degrees C. for molten salt because it's a better coolant.

So you can have higher temperatures with the same fundamental fuel limits which are associated with that coated particle fuel. So if we can improve the heat transfer we can knock down the temperature drops elsewhere in the system to reduce the stress or reduce the difficulty of making a fuel element.

If you're pushing to high temperatures, the goal is to minimize the stretch that's required.

Could I have the next slide?

The other important item is the coolants. Why do we want molten salt coolants?

Well, they allow low pressure operation at high temperatures compared to traditional reactor coolants. The particular salt we've mentioned here we'd operate around 1000 C. It has a boiling point of about 1,400 C, which gives us 400 degrees C. between

the operating point and the boiling point. And of course, that means we're a very low pressure system.

To give you a comparison, sodium unfortunately boils at a low boiling point of 883 degrees C. Hot machine if you're going to make hydrogen. It's unavoidable. And of course water and helium are further on down the loop.

Can I have the next slide?

Needless to say as a new concept we've only begun to examine the safety issues of this kind of reactor. There are many, many uncertainties, but we'll identify those that look potentially attractive, but please recognize we're a very, very early in the game.

Of course, one of the key requirements for both the chem. plant and for nuclear safety we believe is low pressure coolants, subatmospheric coolant. Escaping pressurized fluids provide a mechanism for radioactivity escaped from a reactor during an accident.

A low pressure salt coolant minimizes accident potential for a radioactive transport to the environment.

It also minimizes chemical plant pressurization issues. So for this kind of

application one would like to have very low pressure.

Second, molten salt has a good coolant characteristic to provide high safety margins for many upset conditions.

We believe with a molten salt that we could have significant natural circulation, which would help in certain kinds of abnormal conditions. It has a high heat capacity.

And last, although we don't fully understand the chemistry of it and are only beginning to think about it, molten salts have the unusual features that most fission products dissolve in molten salts, such as cesium and iodine. And hence, the salt itself becomes a --

DR. POWERS: And those particular salts that you've got there, just about everything dissolves, even the things we think are nominally metals.

DR. FORSBERG: I know. This is an unusual coolant. But it's a different approach to safety also, and that's why I mention it because we normally don't think of coolants as fission product absorbers. And in this case the coolant is a fission product absorber.

DR. POWERS: Yeah. I mean, we saw this in

TMI, that you blow efficient products through water. They stay in the water.

DR. FORSBERG: Yes.

DR. POWERS: Okay. And here all you're doing is magnifying that with a coolant that has a higher dynamic range than water does.

DR. FORSBERG: Yeah. I think it's an important issue though because there are different approaches to safety also that you can think about when you go to these high temperatures and when you go to other coolants.

We're using molten salt, but there may be other cases where you can think about fundamentally different approaches to safety than the traditional approaches that we have historically used. When you go to different systems you need to think beyond the box, outside the box.

As I say, we're not far enough into this to give you any answers, but there some interesting potentials. In this particular concept the passive decay-heat removal system is similar of that of other proposed reactors. That is, heat conducts outward from the fuel to the pressure vessel, to the passive decay-heat cooling system, and our conceptual design limits the power to about 600 megawatts, the same as

the HTGR, because the worst design condition for this reactor is you lose the coolant, and then you have essentially an HTGR, a depressurized HTGR. So it has essentially the same temperature units.

I would emphasize very early in our conceptual thinking about this, but what comes out of this kind of thinking is it's a very different kind of system. It has potentially some different approaches to safety that we have not historically used, some chemical approaches.

DR. POWERS: I think it has some interesting safety issues that are peculiar to itself.

DR. FORSBERG: Oh, yes.

DR. POWERS: I mean, this is the classic problem of over-cooling accidents. Start-up is kind of an interesting --

DR. FORSBERG: Yes.

DR. POWERS: -- challenge in this reactor. Start-up and shutdown, both are interesting events in this reactor.

DR. FORSBERG: What he means by start-up is that this material thaws, becomes a liquid at about 400 C., molten salt. So you have a system that is, on start-up when it turns to liquid, is already moderately warm. In fact, it's hotter than any light

water reactor on start-up, which is not your normal way of thinking about things.

DR. POWERS: There are salts that one can imagine that have much wider --

DR. FORSBERG: Yes.

DR. POWERS: -- liquidous boiling ranges than this fluoride system. Have you looked at any of those?

DR. FORSBERG: Not in any detail. So far we've only begun to look at the fluoride systems, and we're looking at this salt and a salt that has zirconium potassium sodium fluoride.

DR. POWERS: Yeah.

DR. FORSBERG: Which of course gets rid of the beryllium issue. So that's why that one's being looked at. There are a variety of other options.

DR. POWERS: Going down -- going to the more complicated ternary systems does get you a broader --

DR. FORSBERG: Yes.

DR. POWERS: -- liquidous range. That particular salt's not a good one for a broad liquidous range.

DR. FORSBERG: Yes.

DR. POWERS: But you can get fairly broad

liquidous ranges so that at least you're start-up might be -- I mean, you've got to worry about how to preheat this stuff.

DR. FORSBERG: Yes. Yes.

DR. POWERS: And if you wanted to use a water-base preheater technology, which I think you would, you want something that melts within the range you can get with water.

DR. FORSBERG: Unusual set of issues. I should mention here, which I didn't mention earlier, one of the desirable features of fluoride salts is they're fully compatible with graphite. Most of you probably are used to aluminum tin cans. Well, aluminum is made by the hull process where you dissolve the aluminum oxides in a fluoride salt that's in a graphite bath.

And the aluminum industry has been using fluoride salts and graphite for a little over a century now. And they're thrown everything, including the kitchen sink, in their graphite baths over a century of experience.

So there's at least a century of experience of running a very wide set of fluoride salts and graphite baths with an extraordinarily wide level of impurities, not intentionally, but

accidentally over 100 years of operational experience.

MR. SIEBER: I presume you pumped this molten salt around the surface.

DR. FORSBERG: Yes.

MR. SIEBER: Are there pumps that can actually do that at these temperatures?

DR. FORSBERG: Yes. Well, we haven't done anything at this temperature. The molten salt reactor experiment at Oak Ridge operated at 700 C. Now, the difference is in that reactor the uranium was dissolved in the salt. There was not a solid fuel element. But that operated about a much lower temperature of 700 C., and of course, nobody has operated a salt system at these temperatures.

MR. SIEBER: You start this reactor with no flow at all.

DR. FORSBERG: That's right.

DR. GARRICK: Are you going to say anything about performance characteristics other than temperature and pressure?

DR. FORSBERG: We're very early in the game, and I wouldn't make any promises that we have any information that would be considered credible. It's very, very early in the game.

DR. GARRICK: Just cycle times?

DR. FORSBERG: That's right. We started this effort about six or eight months ago, so we're very early in the game. Starting with the observation that there some -- maybe some demands for a very high temperature reactors, and if you have very high temperatures, how do you get there with the materials that may exist, and obviously you throw out water; you throw out sodium.

DR. GARRICK: Right.

DR. FORSBERG: And by elimination you're sort of left with graphites and molten salts if you want to really run the temperature up.

The same problem -- it's somewhat similar to the issue of the aircraft nuclear propulsion program in the '50s. They investigated many coolants for an aircraft nuclear propulsion system that had a solid fuel and a heat transfer loop, and the original nuclear work on molten salt transfer was done as part of the aircraft nuclear propulsion system because at high temperatures with low pressures molten salts were the only game in town. There just weren't any other options.

MR. SIEBER: And it operates under a solid coolant condition, no pressurizer or anything. You just pump in --

DR. FORSBERG: That's right.

MR. SIEBER: -- to maintain the pressure. How does it accommodate power swings?

You know, it expands and contracts.

DR. FORSBERG: Yes, it's regular expansion and contraction of the coolant, plus the doppler coefficient of the --

MR. SIEBER: But that could be pretty sever in some accident situations.

DR. FORSBERG: Yes. We're not at the point where we've investigated the details of how you're going to handle these types of events.

MR. SIEBER: All right. Thank you.

DR. FORSBERG: We're at the issue of materials and what materials can you actually build the thing out of that you have a reasonable chance of operating at these temperatures. A 1,000 C. is a very severe operating environment.

MR. SIEBER: It's hotter than a super critical coal boiler.

DR. FORSBERG: That's right.

MR. SIEBER: You get up to those temperatures and the tubes just melt.

DR. FORSBERG: That's right.

DR. POWERS: Have you thought about what

your primary pressure boundary is going to be?

DR. FORSBERG: There are three obvious choices. One is a molybdenum alloy. Then there is some oxide dispersion stainless steels that may have the capability, and then there are also graphites. But we're very, very early. And all of those things are cases where people have shown in the laboratory that the materials are capable of doing something, but nobody knows whether or not they could be made on a large scale or whether you could fabricate them or whether you could convert this into a practical reactor design.

So what we have is materials that are used -- we have -- there are a number of high temperature materials that are used in research applications that operate at these conditions normally, in a research environment, but have not been used in a production environment. So what you have is materials that, yes, some of them have been used for 40 years, but only in a research environment. There's a big difference between research and production.

DR. POWERS: There's a big difference between research environments and flowing, high velocity flows and things like that.

DR. FORSBERG: Yes.

DR. POWERS: In particular, on any kind alloy. The problem here is kind of interesting. It's not carbon extraction, it's alloying-agent extraction.

DR. FORSBERG: That's right. That's exactly right. There is a fair amount of experience based up to about seven, 800 C. Above 800 C., the databases begin to get very sparse.

Could I have the next slide?

If one can produce a high temperature reactor, obviously the options for the production of electricity, that one can use a high efficiency helium gas turbine cycles, conversion efficiency greater than 50 percent, provide isolation of the power plant from a reactor using low temperature drop heat exchangers, and advanced gas turbine technology.

In the longer term there's the option of direct thermal through electric production. That is, no moving parts, methods to produce electricity from high temperature heat. It would radically simplify the power plant design. It has the potential for major cost reductions.

However, it must be emphasized this is a longer term option. Current solid state technology results in thermal electric conversion efficiencies between 20 and 25 percent, and the technology is

clearly not ready to be considered as an industrial technology with those low efficiencies.

If they continue to make progress, one could hope for the possibility in ten to 15 years of a radically simplified power plant.

May I have the next slide?

This shows an advanced Brayton cycle. You have the reactor. You have the turbine cycle, and of course, you have an intermediate heat exchanger loop. In this particular case, the intermediate loop is to separate the high pressure helium system from the low pressure reactor and protect the reactor from transients.

Could I have the next slide?

This shows that the possible use of direct conversion systems, where you'd have a molten salt go through a heat exchanger and produce electricity directly. That is, you have electricity, the molten salt going through a tube. You'd have a solid state converter on the outside of the tube, water cooling on the outside of the solid state converter, with direct production of electric current.

As I mentioned, this potentially is very attractive in the long term, but the technology does not currently exist to get the efficiency high enough

to be of commercial interest. It's only 20 to 25 percent.

But if they make sufficient progress, it has major implications in terms of a radical simplification of nuclear power plants.

Of course that technology would probably also apply to sodium cooled reactors and a variety of other high temperature reactors. And it's a long term option, not a short term option, but something to keep in mind because in 20 years we may have the conversion devices capable of doing it, which would be a true radical simplification.

These molten salt coolants have extremely low activity levels compared to sodium or water.

DR. POWERS: You were talking about sodium just now, so --

DR. FORSBERG: Sodium you would have activity. But molten salts themselves are extremely low activity, far, far less that water or sodium. That's one of the really nice things. That's one of the nice things about molten salts.

MR. SIEBER: The physical size of the converters must be huge to get the commercial levels of power out of them.

DR. FORSBERG: You have to predict what

it's going to be in 20 years, and they've been shrinking dramatically and the efficiency has been going up dramatically, but the question is will that continue for another 20 years. And I don't know.

DR. POWERS: And they produce a direct current; don't they?

DR. FORSBERG: Yes, they produce a direct current.

DR. POWERS: So we get long term direct current transfer with no loss.

DR. FORSBERG: Well, I'm not sure about the no loss part.

DR. POWERS: No, well, you don't have the radiation loss. That's what -- I mean that's the biggest loss you have in --

DR. FORSBERG: Yep.

DR. POWERS: -- transmission. We go back and Thomas Alva Edison may have been right after all, huh?

DR. FORSBERG: That's entirely possible.

Could I have the next slide?

Obviously high temperature creates development challenges. That's the understatement of the year probably. The AHTGR uses some demonstrated technologies. The fuel technology is demonstrated.

The coolant technology is demonstrated. Both require more development work. But the base technologies are in existence.

Of course at AHTGR it requires advanced technology. The most important one is the high temperature materials of construction where there are plenty of laboratory materials capable of doing it, as measured in the laboratory, but have not had the kinds of tests required for long term operation.

And they are not industrial materials at the current time. Lots of issues in terms of system optimization, heat exchangers and particularly the heat exchanger that couples with the chemical plant, and of course lots of work on hydrogen and energy conversion.

Could I have the next viewgraph?

Radio chart implications of hydrogen production. If we talk about an alternative use of nuclear power, there are some very large regulatory implications. The first, most important probably in many respects is that we're talking about different owners, the oil and the chemical industries. Pluses and minuses.

The key item, first item to be noted is they are much larger than traditional utilities.

ExxonMobil last quarter earned $5 billion. They're approaching 300 billion in sales. Shell is a little bit behind, but not far. Very, very large organizations, which means buying a reactor is not a serious capital outlay.

It's a strange way to put it, but in that large of an organization it's not a major -- you know, a CAT cracker in a large refinery costs four billion. Hibernia offshore platform costs seven billion. These are the kinds of things your boards of directors see normally. Oh, it's only like four billion, seven billion, three billion --

MR. SIEBER: Pretty soon you're talking big money.

DR. FORSBERG: You're talking serious money. But it's a different mindset. They're very concerned about, obviously, the cost per unit product delivered, like the cost per million cubic feet of hydrogen. But the capital cost issue would not be a major issue for a chemical company or an oil company, because it's just not that kind of dollars.

The other thing that's important though is they have very different perspectives about risk and how they do business, and I'm not sure how that would interact with the Nuclear Regulatory Commission, but

it's a different philosophy and different ways of thinking about it.

They are, of course, used to handling large quantities of very nasty materials. So in that sense there's a commonality, but there's a different culture. It's a very different culture, and I have no good feel of what that kind of interaction applies, except there would be a lot of grinding of teeth.

DR. POWERS: Yeah. I mean, they deal with a different set of regulatory --

DR. FORSBERG: That's right.

DR. POWERS: -- body, but time scales tend to be a little more shorter term.

DR. FORSBERG: Yes. The second item I'd like to emphasize is both chemical and nuclear safety must be considered, and in my mind it's not clear where the primary hazard is.

The chemical plant must not impact the nuclear plant. Equally important, the nuclear plant must not impact the chemical plant. When you think about boundaries between facilities, you must think about both directions.

And that's something we don't normally do in a nuclear facility. A nuclear facility, well, we can trash a turbine and we don't worry about it. We

can trash a steam generator; we worry about the economic costs. But we don't worry about the nuclear plant in terms of safety, damaging secondary components.

In a chemical plant interface one has to be -- this gets to be a major regulatory issue.

Last, if we're talking about alternative uses of nuclear power we're going to have to do some serious thinking about non-traditional reactors that don't have water, do not have liquid metal and do not have gas.

And that just flows from the different requirements, different applications. We just have to rethink what you want based on requirements.

Can I have the last slide?

Some conclusions. Economic methods to produce hydrogen from nuclear power may provide multiple benefits. Increased gasoline and diesel fuel yields per barrel of crude oil will reduce dependence on foreign oil. It's a long term pathway to the hydrogen economy.

Higher temperature heat allows new, more efficient methods to produce electricity.

Last, reactors with different characteristics may be preferred for such very

different uses. In particular, if you're dealing with very high temperatures and you need low pressures, it may require a fundamental rethinking of how you approach reactor design, and also the regulatory issues associated with those plants because they will be very, very different than the traditional utility type thinking.

That completes it.

CHAIRMAN KRESS: Charles, back in the distant past when I worked on molten salt reactors, we have a saying about talking about hazards. We said -- the saying was "No wing, no sting."

DR. FORSBERG: Yes.

CHAIRMAN KRESS: There wasn't any way to get the fission products out to the atmosphere or there didn't seem to be. The reason I say that is why wouldn't this be an attractive concept for just electricity generation? Because you don't have these extra hazards then of the chemical plant and so forth. And just by itself it looks like would be a pretty dog gone safe, inherently safe concept.

DR. FORSBERG: I think it has many potential attractivenesses. And that's worth considering, but I think an important other consideration is that in this particular case you may

also have multiple markets. And it's those multiple markets that may make it much more attractive for a serious consideration as an advanced reactor concept.

But clearly if you develop this, one will take a very hard look at it as a electric power producing reactor because those safety benefits apply to any other application as long as it doesn't have interface issues.

So, yes, you're right. There are tremendous advantages if you can make it work and then particularly both in the electrical context and in the chemical context.

CHAIRMAN KRESS: And the electrical context you could back off a little on the temperature.

DR. FORSBERG: Oh, yes. Electrical context you can drop probably 200 C. in the temperature and not be too concerned about it.

CHAIRMAN KRESS: You'd still have some sort of interface with --

DR. FORSBERG: That's right.

CHAIRMAN KRESS: -- gas, helium or --

DR. FORSBERG: Yes.

CHAIRMAN KRESS: -- water, one or the other.

DR. FORSBERG: Yes.

CHAIRMAN KRESS: I would think helium with the direct cycle, but --

PARTICIPANT: Tom, there's somebody behind you there.

CHAIRMAN KRESS: Okay.

MR. CARLSON: Don Carlson, NRC staff.

I have a couple of questions about your use of a lithium based salt as your coolant.

DR. FORSBERG: Yes.

MR. CARLSON: Lithium 6 is a strong neutron absorber and produces copious amounts of tritium.

DR. FORSBERG: It's isotopically separated lithium.

MR. CARLSON: Lithium 7?

DR. FORSBERG: Lithium 7. If we -- we're looking at several coolants, some with lithium and some without lithium. The ones that include lithium have Lithium 7 because otherwise the neutronics doesn't work.

MR. CARLSON: Well, even impurity levels of Lithium 6 would give you lots of tritium.

DR. FORSBERG: Yes.

MR. CARLSON: In fact, in the pebble bed

reactor work in Germany, where they were considering processed heat applications, the very small amounts of tritium on the order of 1,000 Curies per year were a concern in terms of getting the tritium into the product gas.

DR. FORSBERG: Yes. That's why we're -- one of the reasons why we consider multiple coolants. Each coolant has particular advantages and disadvantages. Neutronically the lithium beryllium fluoride is a tremendous advantage. But the disadvantages include tritium and a couple of other issues.

The sodium potassium, sodium potassium zirconium fluoride avoids that problem. It has a little more activity in the coolant, has some other issues. So one of the issues in a molten salt reactor is which coolant you want. They all have the same general characteristics, but that's where the tradeoff comes on, coolant A versus coolant B.

You're absolutely right. That's why the coolant decision has not been made and why several coolants are being considered. All fluoride salts, but they have different benefits.

CHAIRMAN KRESS: Other questions, comments?

It's hard for me to see behind me. I have been accused of having eyes in the back of my head.

DR. POWERS: I guess I can't say too -- emphasize too much what Charles' point is, that when we think about new applications, we need to be -- we need to think creatively and innovatively on these things.

Have you looked at some of the silicon nitride, silicon carbide type refractories for your -- as a material?

DR. FORSBERG: We haven't done any serious looking yet.

DR. POWERS: I'm really ignorant in that area, but I know that they have done a lot of things in connection with molten salts --

DR. FORSBERG: Yes.

DR. POWERS: -- with those kinds of materials. And the nice thing about them is at these temperatures they're ductile.

DR. FORSBERG: Yes, I know.

DR. POWERS: They're no longer behaving like ceramics.

DR. FORSBERG: Dana points out the very funny thing. With materials you have to start rethinking. These temperatures, all sorts of

materials that you normally think as brittle become wonderfully ductile. So there's a plus and there's a minus. You have to worry about their tensile strength, but the ductility -- well, gee, like graphite itself. You know, graphite gets stronger and more ductile. It begins to look like a construction material at these temperatures.

DR. WALLIS: Silicon carbide becomes a very good conductor of heat too.

DR. FORSBERG: Yes, yes. One has to be very careful about taking preconceived notions when you move into these systems because if you do you will be surprised. They don't apply.

DR. GARRICK: Have any early looks at this indicated real problems with respect to the interaction of the chemical part of the plant and the nuclear part of the plant?

And if so, does that suggest other concepts that might be attractive with increasing efficiencies and furnaces and electrical systems of going maybe electrical first and then to hydrogen generation?

DR. FORSBERG: People have looked at making hydrogen from electrolysis. The problem with hydrogen from electrolysis is that if you include the

nuclear plant efficiency and the electrolysis efficiency, you're down to a range of about 25 to 30 percent total efficiency, whereas the direct cycles have about 50 to 60 percent efficiency.

And the general feeling among most people who have looked at this issue is that that factor of two in efficiency drop makes electrolysis very difficult to ever become competitive in production of hydrogen.

DR. GARRICK: That's unless that technology --

DR. FORSBERG: That's right.

DR. GARRICK: -- improves. And there's real safety problems between the --

DR. FORSBERG: That's right.

DR. GARRICK: -- direct cycle.

DR. FORSBERG: That's right.

DR. GARRICK: Yeah.

DR. FORSBERG: These direct systems have not really been explored in any detail. Now, we have looked at some very unique type of heat exchangers between the chemical plant and the nuclear plant. In particular, we've been doing some examination of using radiation heat transfer from the primary system salt coolant to cold pipes that contain the actual chemical

reagents. Instead of a mechanical heat transfer, literally have the salt tubes radiate heat in infrared to absorber tubes that contain the chemical reactors so that you essentially have no physical contact between the reactor pipes and the chemical plant pipes, and that begins to look potentially applicable above about 900 degrees C.

Below 900 degrees C. the heat transfer rates are not very attractive. But the heat transfer rate goes up as T to the 4th, and somewhere around 900 C. you get heat transfer rates that begin to look attractive for radiation heat transfer rather than conduction heat transfer.

CHAIRMAN KRESS: Have you looked at that marvelous material, graphite foam, that's being worked on at Oak Ridge?

DR. FORSBERG: We've thought about it.

CHAIRMAN KRESS: It seems to have an extremely high thermal conductivity.

DR. FORSBERG: Yes. We've thought about it. It's a possibility. We're still very early in the understanding the requirements for the chemical plant. Remember the chemical plant, we not only have to transfer heat, but those tubes in the chemical plant have catalysts in them and chemical reactions,

and so they have their own set of design constraints independent of the reactor.

But we have been looking at alternative ways to couple the plants, and we've looked at the conventional heat exchangers and also this issue of radiation heat transfer, which sounds like a very unusual heat exchanger, but when you run through the numbers it begins to look like, gee, that's rather amazing. It may be viable.

CHAIRMAN KRESS: Back to the subject of this particular Subcommittee meeting. What do you see as regulatory challenges or implications of -- if such a plant ever came before NRC?

DR. FORSBERG: Well, the first institutional one, which would be probably the most difficult one to deal with, is relationships between the Environmental Protection Agency, OSHA, and the NRC, because the chemical plant comes under a different regulatory structure than the nuclear plant, and there's been some history to indicate that it is sometimes difficult to work between different federal agencies with different philosophies.

So that's clearly the first thing that shows up.

The second one, which is related, would be

the need for the technical staffs of EPA and the state regulator that deals with hazardous materials to work with the NRC in whatever type of analysis, safety analysis, would be required to assure that all the safety issues are properly addressed, both in the nuclear and chemical side and on the interface.

So I see that the initial problems as both institutional and technical because we have a separate structure for regulation of nuclear versus chemical.

Now, that's not true in some other countries. The Brits have a unified structure, in which case no problem. But for the United States where we have, for one reason or another, have got two different organizations to deal with hazardous materials, this would be a significant interface problem.

CHAIRMAN KRESS: Are there other questions, comments?

Seeing none, thank you very much, Charles.

And we'll move on to the next item on the agenda, which is, I think, an NEI presentation, I believe. Yes.

DR. WALLIS: Are you the next speaker? All yours. Do you want this seat?

MR. HEYMER: Can you hear me?

Good afternoon. My name is Adrian Heymer. I'm a pro jet manager at NEI in the risk informed regulatory group.

We deal with Option 2, Option 3, which is risk informing the SSCs governed by NRC's special treatment requirements, risk informing NRC technical requirements, a few other risk informed activities, and we've been matrixed across to the new plant group within NEI dealing with the new plant regulatory framework.

Since we're in the risk informed group, one of the things that we've come up with is that we feel that we should start with a fresh sheet of paper as we deal with the regulatory framework for new plants, especially since we're not dealing with necessary light water reactors with different -- dealing with different types of reactors.

And that really comes about because we don't want to be too burdened with current interpretations and current philosophies or ingrained or established thought processes necessarily.

We have run into some cultural issues as you go through any change process, and these have been difficult to overcome.

So starting with a clean sheet of paper we

hope that we start off with fresh minds, but build on our experiences of the past so we don't actually lose those, but don't become ingrained with them.

Establishing new wired thinking or a new framework provides some form of measure against which we can set our requirements, requirements being in the regulations and the general design criteria and what we believe are general operating criteria.

And I think it provides a platform for a better understanding between the people who are trying to get a license or a certification and the regulators themselves.

Next slide.

So not only does it provide a basis for the regulatory positions, but it helps the industry establish its own positions as we work through the development of the framework so that we can come up with, as we said, a generic framework to cover all types of plant, and some people think we can achieve that goal and other people think we can't.

And I think it depends upon the degree of specificity that you get down into, whether or not you put the real details in the regulations or do you put the details in the regulatory guide.

We think there's a need as you go through

looking at where we are today in the current plants. We've got an oversight process which is risk informed. And we have regulations which are very much deterministic. There are some that are moving towards a risk informed world, but we haven't quite got there, and in fact we are struggling in some of those areas.

And so it would bring some degree of consistency between an oversight process and the regulations, the reg. guides and the way we run and regulate out plants.

And so what we're looking at is to start with, and again, it's a starting point for discussion, is to use the framework that was being developed for the oversight process, to start not only in the industry-regulatory interactions, but sort of the intra-interactions between the industry and we hope for the discussions within the NRC staff as we move forward.

Why do we want to start there?

Well, quite simply it's out there today. It is a risk informed type of framework.

Does it cover everything? No. And I'll get to that in a minute.

But it has, if you like, broken the ice as regards the changing the cultural mentality that

exists within the industry and the regulatory establishments, and I think that's only a natural resistance. There's a natural resistance to change that you see anywhere that must be overcome.

Next slide.

So we want to be generic to all types of reactor. We think it's good if you start from the top and slowly work down and cascade out. And many of our concepts, I think, are reflected in some of the presentations I heard this morning. I wouldn't necessarily say we're going down the same path as everyone. I heard this morning all those paths, but certainly there is a common flavor that if you take it at a high level, that there is a convergence of thought as we move down towards establishing the basis for the licensing a new reactor in the United States.

And so we start with the adequate protection of public health and safety, and there are some safety goals that are associated with that.

Are they the same safety goals as we have today? And we believe at the moment they are. It may be more towards a radionuclide release criteria rather than a core damage frequency, but it's along those lines, and those goals have been established.

We do believe you need a new set of

general design criteria, although I do agree with I think Mike Golay this morning, who said the general design criteria, if you read them, they are very motherhood statements.

And we've got an example towards the back end of the presentation of where we might go in that. And I think one of the items that we're going to struggle with as we move through this is how specific do we get in the regulations as opposed to trying to keep it general because the more specific you get, the more difficult it is to say, "Well, is this going to be applicable to all regulations, all types of plants, or not all plants?" And then how do you work that one through?

There isn't really much or until recently been much in the regulations regards general operating criteria or operating regulations. The regulations were really set in place to deal with design and construction of plants, and we try to sort of adjust and bend the regulations into an operating mode.

And I think there needs to be some element in there. I think when you look at the maintenance role and you look at 56(a)(4), the maintenance rule, which is if you lack a configuration control element, we've begun to put those measures in place.

Whether we need some more or not, I don't know. But I think we do need to look at the operating side as well as the design and construction.

It should be a risk informed and performance based. We've struggled with what does that mean in the regulatory world. But I think building on the experiences that we've had with Option 2 and Option 3, with the oversight process, I think we can come up with a good set of regulations.

And then beneath that, you're going to get a series or reg. guides or implementation guides that would be, first of all, regulatory specific.

So how to implement this regulation, and that's where you may get down into the various different design characteristics. So you might have one regulation, but it may have two or three reg. guides depending upon the type of reactor that you are talking about. And then you'd have design specific applications dealing with that, that design element.

So that way the regulations are general. They're generic. They cover everything. It's a set standard, but it is fairly high level, and I guess there is an issue out there as regards finality and certainty, is the more general you get, the more reliance you're putting on reg. guides, and is that

regulations and is there a finality in the legal world?

And we leave the lawyers to deal with that. That is an issue that has been mentioned on occasions.

I just want to touch a few moments now that I've said what the concept is and we're moving forward. We are in the process of establishing a task force made up of industry participants to take a look at what the framework would be, how detailed it should be, and give us some input so that we can provide something as regards an input to the regulatory process and the development process either at the end of this year or the early part of next year.

But is that the end of the game?

No, it's not. It's only really the start because in order to move forward, I think, you really need some active project. Otherwise, you'll, as you move into the regulatory discussion, you're dealing with somewhat of the theoretical hypothetical type of interactions that have gone on. And I think if you have a specific program to lean towards, to join with, that you force yourself to come up with -- you force yourself to a decision point, and you have to make decisions.

And we can always get smarter as day goes on, but at least you come up with a decision. You come up to a starting point. So what we see as a proof of concept type of application, whereby very similar to what happened in license renewal and Option 2 for South Texas, that we hope is a little bit more expeditious than Option 2 or the license renewal approach, whereby you come up with an idea and you come up with a framework or you come up with a regulation. And then you move forward with a specific project.

And the lessons learned from that specific project and those specific interactions between that licensee or designer and the NRC get fed back into the framework, and you adjust as you move forward.

CHAIRMAN KRESS: When you say use license renewal and Option 2 models, you don't mean the specifics in there, do you?

MR. HEYMER: No, I mean --

CHAIRMAN KRESS: You mean as a process.

MR. HEYMER: As a process.

CHAIRMAN KRESS: As a process.

DR. APOSTOLAKIS: I think what you described, Adrian, is really the idea of a pilot. Is that --

MR. HEYMER: You can call it a pilot. Pilot's probably too strong a term. We're looking more or less at proving the concept, proving of the framework, proving that the regulatory process as the process is being developed.

And so that's why we think it's important to have representation into the development of the industry thought process on the framework from Exelon, from Westinghouse to cover IRIS, to cover the AP 1000, to cover the pebble bed from General Atomics, et cetera.

So that you get those thought processes in and there's the concept; that's the framework. Then you go and perhaps test it with a few applications and see how it actually works out.

When we've used the term pilot in the past internally, some people have thought that was perhaps a too definitive term as you are definitely testing the regulation.

Here you are testing more the concept, and then the regulations would be developed from the pilots or the proof of concept projects moving forward, and what you've come up with is a draft framework.

And I think if you see or the way we see

it going forward is that there -- we have the regulatory interaction. We provide input to the regulatory process. They come forward with an advanced notice of proposed rulemaking. That goes out of the street, has public involvement. It comes back; there'll be more discussions and sessions like this.

In the meantime, the pebble bed and others are moving forward, and they're talking about specifics, and that gets fed back into the process, and by that time, some point in time, you come forward with a notice, if you like a mega-notice to proposed rulemaking.

Now, whether it's on specific regulations or a new part to the regulations, I don't know. But I think at the moment we're thinking about a new part to the Code of Federal Regulations to deal with these new types of reactor designs.

CHAIRMAN KRESS: For advanced reactors.

MR. HEYMER: Yes. Advanced reactors.

CHAIRMAN KRESS: Part 6(e) something or other.

MR. HEYMER: Yeah, 63.53 or whatever, yes.

MR. SIEBER: It seems to me that licensed renewal never struck me as particularly risk informed or performance based. How does that act of a proof of

concept?

MR. HEYMER: Well, in licensed renewal there was a draft regulation, and then some plants came forward, and one or two dropped out, and then Constellation and Duke took up the ball, and there were active interactions going on on renewing a license, a specific license at the same time as we were trying to work out the implementation details associated with the regulation, and in fact, while the regulation in some cases was being changed.

And so that's how I see it's more of a process issue. I agree with you, it's --

MR. SIEBER: It's not risk informed.

MR. HEYMER: It's not risk informed, but it's -- we're trying to look at the regulatory process as well as the specific regulations dealing with that.

DR. APOSTOLAKIS: Adrian.

MR. SIEBER: Thank you.

DR. APOSTOLAKIS: Everybody keeps saying risk informed performance based, but can licensing really be performance based?

MR. HEYMER: I think in the context of purely the licensing action, no, but what follows on afterwards is.

DR. APOSTOLAKIS: Oh, the regulatory.

MR. HEYMER: Yes.

DR. APOSTOLAKIS: The oversight, sure. We are not dealing with that now. You are dealing with licensing, aren't you?

MR. HEYMER: Well, we think that if you put a new Part 63 in place that there should be some element dealing with operational aspects, and so that's where we see that coming in, and there's also a probability that if you look at the Part 52 process in ITAAC, that is akin to a performance based element to a certain extent.

I mean, you have the ITAAC which are there.

Okay, next slide.

This is a pictorial representation of the process that we've -- I've just discussed. I spoke about coming down from the top, but equally you've got the reg. guides and the specific design, specific guides from the bottom and it's -- if you like, we could have drawn it as a pyramid, but it was easier to put all these words in place.

What are the safety areas and what is the framework?

And we think they are the same as the oversight process, and if you go to the next slide,

this is what the regulatory oversight process is as of today. Does it cover everything in a regulatory regime?

And the answer is, no, it doesn't. There are some things missing, and I think if you start looking at some of the advanced reactor types that we have today, are we talking about mitigation systems or mitigation processes?

And by that I mean perhaps there isn't a system to mitigate the initiating event. Perhaps it's designed into the plant.

There's also an admin. element that's missing that would cover some of the reporting requirements, configuration and change control, cover quality assurance.

And so if you go to the next slide, please, this is what one might look like, and we haven't had very much discussions totally within the industry. There are rather a lot of boxes and it's a very complex slide.

Some things I want to point out is I don't think it's mitigation systems. It's mitigation in general, and we need to perhaps define what that is.

And then under the administrative area, you have a whole section of issues here, some of which

could be risk informed. Others, which will probably just almost be lifted carte blanche out of a Part 50 space, and whether or not we do that is still to be determined.

And one of the other issues is how would we deal with the Part 52 interface. And I think there is a way to deal with that as you go through the rulemaking process with the conforming change.

But some of these, like the reporting elements, tech spec amendments, and things like that, I think there is an opportunity to risk inform those activities.

I believe there is some internal work done that showed that 40 percent of all tech. spec. amendments aren't really associated with safety, and something like 70 percent of all LERs and reporting requirements from 50.72 and 50.73 aren't associated with safety significant issues.

So I think that's something that we should take a look at from an administrative burden that perhaps we need to place the emphasis of our resources elsewhere.

As you go down here one other point is that on radiation safety, we are looking at an activity to take a look at Part 20 and see if we can

improve on that regulation, and perhaps make it performance based, building on what we've learned over the last 35, 40 years of implementing those regulations within the industry.

So that is an addition to what we have here.

How long is this going to take?

Well, as I said, we're hoping to have some recommendations or proposals into the NRC staff towards the end of this year, early part of next year.

CHAIRMAN KRESS: Whenever I've seen this slide or the previous equivalent, without the added parts, I've always thought between that top box and the three boxes below it, and now you have four, that there's a missing set of boxes. And that is what is the regulatory objective of reactor safety.

Is that the safety goals, for example, or is it something else?

So what's the regulatory objective for radiation safety? Is that 10 CFR 100 or is it -- and similarly for the safeguards.

I've always thought that it's that missing line in there that gives us a lot of trouble. And I wonder if you guys had planned on adding something in there to define what we mean by those three boxes, or

the four.

MR. HEYMER: Well, when you look at the -- when you look at the oversight process, there was an attempt to define what is associated with those -- it was three boxes, but those -- that second layer, and associated with the attributes and an attempt to define what they are within those areas, and as they come down into the next box, which is the cornerstone.

We can take a look at that and see, but that's a good input.

DR. APOSTOLAKIS: I had a similar comment, maybe expressed in a different way. The fundamental difference between what you're trying to do and what the oversight process does is that the oversight process starts with an existing system that has been licensed and works with changes from that.

As such, the need for these goals that Tom mentioned is not there because now, you know, I look at the particular plant, look at the initiating events. There is a certain rate. Although the system is not plant specific yet, they're going there with design specific thresholds.

But if you think about this framework being used to license a new concept, then all the questions that came up this morning during Mike

Golay's presentation come back here to haunt you.

In his presentation, Tom asked what is the allocation to LOCA's of, you know, the goal and so on. Well, here because you are starting with a new sheet of paper, you have the same questions. How much should I tolerate of the frequency to go to the initiating events, to the mitigating systems, to the barrier integrity?

So it's really something that's -- I mean, I think you have very good intentions, Adrian, but the really tough questions have not been addressed yet.

There is a fundamental difference between overseeing something that's already there and has been licensed and starting with something that's coming out of the blue, and I don't know. I don't know what the initiating events are for the pebble bed, you know.

MR. HEYMER: You make a very good point, but it's not literally coming out of the blue. We have --

DR. APOSTOLAKIS: Well, it's maybe blue and red.

MR. HEYMER: -- experience that we can build on, and we can start establishing some of those.

DR. APOSTOLAKIS: I am sure we can, but I --

MR. HEYMER: I mean, I think if you sat a group of people around a table you could come up with those type --

DR. APOSTOLAKIS: I think what I'm saying is that you are a little -- overplaying it a little bit, unintentionally, the significance of the fact that this framework has been used in the oversight process. The fundamental issues are there.

If you look at the report the staff developed on Option 3, essentially they follow the same approach, but they dare go beyond that, and I think you guys are a little cool towards the other stuff they did.

If you look at what Golay did, well, it's buried in there. I mean, it's the same idea. So I think this is a good starting point, but I wouldn't overplay the connection to oversight. It's a very different regulatory problem. I guess, that's my impression.

MR. HEYMER: That's good insight. It's good input. I'm going to take that.

DR. APOSTOLAKIS: I came on too strong, Adrian. I'm sorry.

MR. HEYMER: No, no, no. Please, please.

DR. APOSTOLAKIS: It's just that I don't

like it.

(Laughter.)

DR. APOSTOLAKIS: No, I'm sorry. No, I didn't mean that. Take it back. Take it back.

MR. HEYMER: But from the cornerstones we would develop specific criteria and specific regulations, which would feed off the cornerstones in those areas. And we did a -- what we just to see how it would pan out, we looked at -- we took the current regulations, of which there is about 160 general design criteria regulations.

DR. APOSTOLAKIS: One other question.

MR. HEYMER: Yeah?

DR. APOSTOLAKIS: What we're seeing on the board now on the screen is the NRC oversight. Now, when you go to yours, you are adding a fourth element in the second tier, but how about the bottom?

What happened to human performance, safety conscious work environment, and problem identification or resolution? Are you going to handle those in a different way?

MR. HEYMER: Problem identification and resolution is in the quality assurance element.

DR. APOSTOLAKIS: Oh, it's --

MR. HEYMER: Yes.

DR. APOSTOLAKIS: Oh, okay.

MR. HEYMER: And we see training would be down in there as well. And so --

DR. APOSTOLAKIS: I see. So you are covering those with the new boxes?

MR. HEYMER: Yes.

DR. APOSTOLAKIS: Okay.

MR. HEYMER: What we did is we took the cornerstones, and we added a few areas to them, such as administrative, financial and operational, and we took the current regulations, and we attempted to say which box would they fit into.

And we soon realized that some of them actually fit into more than one box. That's why if you add up the number it does actually come out to more than 160.

But it's interesting to see where the regulations are focused at the present time, and perhaps that's quite proper because it's a legalistic regime.

DR. APOSTOLAKIS: But again, why is that? I mean, I appreciate the point you're making, but why should I be surprised?

I mean, here is a technology that, you know, the safety issues are really very low

probability, high consequence events. Very low probability means that I really don't have a statistical record, right?

So it makes sense for me to have lots of administrative controls, doesn't it? Unless administrative means something else that I don't understand.

MR. HEYMER: Well --

DR. APOSTOLAKIS: Doesn't it?

MR. HEYMER: Administrative controls dealing with reporting, dealing with how to make out --

DR. APOSTOLAKIS: Those I understand.

MR. HEYMER: -- dealing with how to update the FSAR.

DR. APOSTOLAKIS: So what you're saying is we are -- we got them carried away?

MR. HEYMER: I think we may have done in some areas. Now, on the other hand, if there's some administrative requirements to keep the regulator informed, I think the regulator should be informed of those matters that have safety significance for the plant.

DR. APOSTOLAKIS: Sure.

MR. HEYMER: And I think that's -- I mean,

when you look at some of the regulations and they're ten pages in length and very complex and difficult to read, it's certainly not nighttime reading. Then I think we can do a job of streamlining those regulations and still being able to focus on those matters that really do present a risk to the public.

DR. GARRICK: And there are those precursor events for which there is information and a relatively high frequency.

MR. HEYMER: sure.

DR. GARRICK: And of course, the risk informed is making the connection between those and the events of interest.

DR. APOSTOLAKIS: No, I understand that, but all I'm saying is that I'm not really surprised that the highest number is down there in the administrative thing, because you are dealing with rare events.

Now, I do agree that instead of 68 probably it should be 43. But I still think it's going to be a high number.

MR. HEYMER: Yes, but hopefully not as high as proportionally as what we've got here, and plus also we recognize, as I'm sure you do, that the current regulatory framework is not really that risk

informed.

DR. APOSTOLAKIS: No, no.

MR. HEYMER: And so it's fine. But it was just to show you -- show us where it comes in and the fact that we thought that it does fit.

On the next slide what we've attempted to do, just as a point of discussion, is just to chalk out, and we've done this for a couple of regulations, is to calk out what might a regulation look like and is some associated with configuration management?

And a lot of people in the past 20 years or so have got into some problems about losing configuration control and what that means in the plant.

DR. APOSTOLAKIS: I must say --

MR. HEYMER: And that includes risk configuration management.

DR. APOSTOLAKIS: I though your -- the emphasis of your talk was going to be on licensing of the new concepts. But yours seems to be attacking the whole thing.

MR. HEYMER: It's a regulatory --

DR. APOSTOLAKIS: Does Exelon really worry about how the NRC will regulate the pebble bed after they get the license?

They worry about it right now?

MR. HEYMER: They worry about it right now, but if you're dealing with -- and that's why I said when you develop the framework, you have people like Exelon moving out and testing the process on a pebble bed, and there's a feedback process that comes in and you can adjust.

Now, once you start operating those plants, perhaps there's some additional -- just as there is today. We get smarter as we go on.

DR. APOSTOLAKIS: So how is this different from the current maintenance rule? Isn't that what it says?

MR. HEYMER: It's very little different. I mean.

DR. APOSTOLAKIS: Okay.

MR. HEYMER: I mean, it's just an example of we're already there in some of these areas. Okay. Now, some of the areas we're going to do some more work, but it would be -- the purpose of this slide is to say that it is not ten pages. It's a bit more than ten words, but it's not going to be a detailed, very specific regulation, like Appendix R, like 50.55(a) for codes and standards.

We think it should be a fairly general,

high level sort of regulation that we're talking about here.

MR. SIEBER: Would this take the place of 50.59?

MR. HEYMER: This could take the place of 50.59.

MR. SIEBER: Well, this is pretty general.

MR. HEYMER: I mean, this is general. We hadn't really thought that point all the way through, but we thought if you're dealing with configuration control, configuration management and change process, if you're dealing with something akin to what we've got in (a)(4) with the maintenance role, perhaps this is all that you need.

Now, we probably need a few more bullets than what we've got here, but as a starting point, just to oil the brain up and get it moving, so to speak.

MR. SIEBER: I would imagine that once the lawyers got through that, it would look pretty much like 50.59.

(Laughter.)

MR. HEYMER: That's why we want a risk informed and clean sheet approach, because we want to be able to say, "Okay, is it risk management? Are you

managing the risk profile of the plant?"

And if you are, perhaps it's just something like this in a reporting element. So it's a question.

DR. POWERS: Can you tell me what exactly your intention is? Assess and manage, what -- how do you view those?

I mean, assess could be, yeah, it's a change.

MR. SIEBER: Tells you what desk drawer to put it in.

MR. HEYMER: Underneath this there would be a regulatory guide that actually defines the specific process and would put the change control criteria down in there. So it wouldn't necessarily be in the regulation. It would be in the regulatory guide.

DR. POWERS: The regulatory guides of course are just advice to the staff. I mean, advice to the licensee.

MR. HEYMER: And the licensee would make a commitment.

DR. POWERS: He would make a commitment upon that.

MR. HEYMER: To have a process that

satisfies that reg. guide.

DR. POWERS: What I'm trying to understand is what do you see him committing to do?

MR. HEYMER: Committing to meet the regulatory guide, and as I said at the start, there is a debate about how specific we get to, and I think that point was made by Mike Golay, and I think it was this morning about how specific do you get in items such as the general design criteria, because when you look at the general design criteria, they are very motherhood statements and you could say, "Well, yeah, this can fit any type of reactor."

Now, if you start getting the next step below that, you begin to get more specific, and then you begin to run into the different types of designs and perhaps different facets of what is covered by the regulations in those designs.

And so that's the reason why I put this slide and the slide after it up, is to really emphasize the point of what we're going to struggle with, I think, as we go through this, is how much detail you get into as you develop the new regulation.

DR. APOSTOLAKIS: The major challenge right now, it seems to me, is licensing a new concept. And you are really ahead of the game because -- not

ahead of the game, but you are looking after licensing perhaps because it's easier to start with, because it's very close to what we're doing now.

I mean as you said, this is very close to what the maintenance rule is. So this is the easy part and, you know, I also like to start with easy things.

MR. HEYMER: You go through and one guy goes through and he has a license, but then you want a standard by which other people coming forward can be judged against, and this is what we're trying to put in place.

DR. APOSTOLAKIS: But I think -- I thought, at least, that you were going to place more emphasis on the actual licensing process. How do you risk inform that?

MR. HEYMER: Well, the licensing -- you mean the Part 52 process or the Part 50 --

DR. APOSTOLAKIS: Yeah, if you want to go part --

PARTICIPANT: The design certification.

DR. APOSTOLAKIS: Okay, the design certification process.

MR. HEYMER: And just as Part 52 references Part 50, I think Part 52 would reference

this new process. I mean there's going to be a comparison of -- as you come in, there's going to be a comparison of the proof of concept project coming in with what they believe should be the framework. You've got the existing requirements, and you've got the development of this new regulatory framework set of regulations.

It's like a three cornered input, and the initial comparison is going to be the new guy coming in with the new framework, which is developed predominately by that licensee, and which that license's input would also feed into the general industry view.

And you've got the NRC with their current regulations, and you want us to say you meet the current regulations or take an exemption from them, or you come up with another set of regulations. And what we're looking at here is what do we come up with as regards another set of regulations.

DR. APOSTOLAKIS: Again, if I look at -- I mean, if I look at the figure with the expanded framework of the oversight process --

MR. HEYMER: Yeah.

DR. APOSTOLAKIS: -- I mean, all the questions that came up this morning and yesterday,

again, you will need to a major effort to address them. If I look at initiating events and mitigation and barrier integrity and emergency preparedness, now I'm told that in a new concept I really don't need to worry too much about the containment, additional containment.

I mean, I will need guidance to be able to evaluate that in a risk informed way.

MR. HEYMER: I think the containment issue is not necessarily linked to the containment. It's linked to the -- it's linked to the barrier.

DR. APOSTOLAKIS: Yeah. The barrier. So, you know, that's what I'm saying that I said earlier. For an existing plant, I already have an allocation if I were to use that way. We know from the existing PRAs, 103 units and so on, roughly how much of the risk is due to initiating event frequency, roughly how much due to the mitigating systems, the containment, and so on.

Now, in a new design somebody tells me, "I'm going to keep the core damage frequency to ten to minus five," which is, you know, maybe better than some of your plants now. But all the ten to the minus five comes from the initiating events. I'm going to make sure that those don't happen.

Now I'm having a problem with defense in depth, you know, which I didn't have in the oversight process because the plant already existed.

Now, that's the fundamental problems that will take time, I think as these, resolving those, and some guidance from you guys would be great actually.

MR. HEYMER: As regards defense in depth, you have -- I mean, that's linked to uncertainty in the consequences, and you k now, the higher the uncertainty and the larger the consequences, the poor --

DR. APOSTOLAKIS: Right.

MR. HEYMER: And what we see is probably more of a risk based and then a deterministic being laid on top of that from a defense in depth perspective as opposed to the other way around that we've got it at the moment. We have a deterministic set of regulatory requirements, and we're trying to layer or at least impose a risk informed set on top of those.

DR. APOSTOLAKIS: I understand that. I guess my point is that at this stage you have not really attacked the most difficult questions of --

MR. HEYMER: Well, I think it comes back --

DR. APOSTOLAKIS: -- and that's fine, I mean, as long as you agree that you have not.

(Laughter.)

MR. HEYMER: It comes back to the point you made on the box diagram about defining what reactor --

DR. APOSTOLAKIS: I'm sorry. Comes back to where?

MR. HEYMER: To the point you made on the framework diagram that's got the admin. box in it where you talked about reactor safety, radiation safety --

DR. APOSTOLAKIS: Yeah.

MR. HEYMER: -- is defining, better defining what those are.

DR. APOSTOLAKIS: Okay. So you will do that?

MR. HEYMER: Yes. I mean, we can do that.

DR. BONACA: Although I must say that I still am confused about what's different in this from the previous system. I mean I could take the previous -- the existing system and then put it on --

MR. HEYMER: From a framework perspective, not much. It's when you get down to specific regulations you begin to see --

DR. BONACA: Okay. Well, I can understand that. Yeah, all right. I don't quite understand from the examples where the differences may be, and I really couldn't figure it out. But I understand your intent. I mean, clearly you said before that it has to be risk informed and you're looking.

The reason why I bring it up is that we saw a number of innovative processes this morning, and the concern I have is that you can put in pricing framework now that may stifle, in fact, the credibility of some of the innovative cultures as much as the old system stifles.

If you step ahead and make, you know, a framework too articulated here. I don't know. It seems to me --

MR. HEYMER: Well, when you look at the framework and you see the current regulations and requirements, I would agree with you.

If you look at the frame work and say there are alternative regulations or a different set of regulations, a different set of design criteria, I think that gives you the flexibility.

If you go to the last slide, this is one we came up with protection against natural phenomena. I mean, it really brings home Mike Golay's point.

It's how specific do you get because this is almost identical to what's in the general design criteria today.

But do you break it down into separate elements or do you stay with a simple general statement like this?

And that's one of the things I think we're going to struggle with, but when you look at you're going to protect against natural phenomena, I mean, I think that's what you're going to have to do.

DR. POWERS: But it's the historically reported. I mean, this is --

MR. HEYMER: Well, that's the reason why initially we were going to stop at halfway through it where it says capability to perform the safety functions, and then we added on the last of it to say, you know, do you go back to the historical or is it just probabilistic or what, and that's the reason why we put the last bit in.

DR. POWERS: What it means is that sites where there hasn't been anybody living or reporting for have much less severe criteria than where I have a long history.

MR. HEYMER: It depends on how far back you go. I mean, a lot of those histories go back

before a nuclear plant was actually put in place.

DR. POWERS: Sure. I mean, I'm think of earthquake. We go back farther than that.

MR. HEYMER: Oh, a lot farther, yeah.

DR. POWERS: And so why now are we going to drop it down to just the historical record on earthquakes? There's not enough history to get any kind of statistics on just earthquakes.

MR. HEYMER: Well, I mean, that's a debate that I think we're going to have, but it's just to try and highlight. The reason why we wrote it this way is just to try and make the point of are we going to go back.

DR. APOSTOLAKIS: I can't remember right now, but how is this different in a fundamental way from the existing practice regarding earthquakes?

MR. HEYMER: We didn't say it would be that much different.

DR. APOSTOLAKIS: This is almost the same, is it not?

MR. HEYMER: Yes.

DR. POWERS: No, no. If I have to adjust to use the historical record on earthquakes?

DR. APOSTOLAKIS: They define the safe shutdown earthquake using the history of the site,

using the history. That doesn't mean you go strictly by what happened, and they say, you know, you're going to have what, a margin for uncertainty and so on?

It's really no different.

DR. POWERS: I think it's a big difference.

DR. APOSTOLAKIS: Oh, no.

MR. SIEBER: The flood area --

DR. POWERS: If I have to live on what's historically reported rather than the history of the site, that's a big difference.

DR. APOSTOLAKIS: Oh, oh, oh, I see.

MR. SIEBER: The flood area is quite different. For example, I know of one plant where they postulated the breakage of a major upstream dam to define what the flood level would be, and of course, there's no historical record that that dam ever broke.

So, you know, that prevents you from postulating that might occur, but have not yet occurred as part of the protection of the plant.

DR. APOSTOLAKIS: And what safety significant -- do you mean risk significant --

MR. HEYMER: Yeah.

DR. APOSTOLAKIS: -- in the sense of

Option 2?

MR. HEYMER: And the reason why I put that down is because when we told -- we mentioned about safety related or safety --

DR. APOSTOLAKIS: Significant.

MR. HEYMER: I know. We were just -- we put safety significance trying to emphasize that that's in tune with the Option 2/Option 3 type of terminology.

Now, you could say risk significant in terms of the maintenance rule. It would come up.

DR. APOSTOLAKIS: No, there is a slight problem here, I think, in the sense that I cannot determine what is risk significant or safety significant until I have a PRA which will tell me when the PRA will be based on the actual design, but now I'm supposed to use the results of that PRA, in fact, to create the knowledge base for the PRA.

MR. HEYMER: Well, it's an iterative process.

DR. APOSTOLAKIS: So you start with one and do it and do it again?

MR. HEYMER: Yeah, and there is experience. I mean, when you do -- you know.

DR. APOSTOLAKIS: Well, yeah.

MR. HEYMER: You just don't say, "Well, I'm starting with a new design. What have I got?" I mean, there's --

DR. APOSTOLAKIS: I must say overall though, Adrian, maybe it's too early in the process, but I, frankly, thought you were going to come up with something that's a little more daring. You are really sticking to the existing regulations which you have blasted in the past. We must be doing something right.

(Laughter.)

DR. APOSTOLAKIS: You really like it.

MR. HEYMER: But there is specific language in the regulations.

DR. GARRICK: There is one big difference, George --

DR. APOSTOLAKIS: What is?

DR. GARRICK: -- that I am detecting, and I think it's one of the things that bothers you, and that's the issue of allocation. I get the impression that they're talking more in terms of general performance goals and not so much in terms of allocation down to levels that partition those or apportion those to lower levels of the plant.

DR. APOSTOLAKIS: I think whether they're

doing --

DR. GARRICK: And that's a big difference.

DR. APOSTOLAKIS: No. I think what they are doing is they are not facing it. The issue will come up, eventually will come up. You don't have to allocate, but de facto by doing the things that presumably they will propose, you will have an allocation, and the question will be a petition, if you want. Is that good enough?

Because if I go back to the boxes, again, if they come back and tell me that all my eggs are in the initiating event basket, why? Because this is what the various criteria produce. What am I going to do as a regulator? Am I going to accept that because that's how it turned out, or what?

I know that you have an aversion, John, to allocating risk from top down.

DR. GARRICK: Right.

DR. APOSTOLAKIS: And I appreciate that, but I think at some point you have to -- I mean, let's say you go purely by engineering and you build something because it's feasible. You have to decide whether the design is acceptable, which in some sense brings that issue back into the forefront of --

DR. GARRICK: I'm not saying you shouldn't

strive for a balanced design. I'm just saying that there are two ways of looking at this. One is if you really are trying to implement a risk informed and performance based approach, then you can take that at an overall performance and an overall risk level.

You're got a risk standard and a performance level, and you go after it, and another way is to give it more of a bottoms up treatment.

And it's more difficult, especially when you're talking about different designs, to think in terms of an allocation process.

DR. APOSTOLAKIS: And I agree with you. I fully agree.

DR. GARRICK: It just will not make sense, and --

DR. APOSTOLAKIS: Exactly.

DR. GARRICK: -- it won't work.

DR. APOSTOLAKIS: I think it should be a check at the end whether you really -- allocation really means difference in depth if you want to think about it that way.

DR. GARRICK: Okay.

DR. APOSTOLAKIS: It's not something that should drive you. It should be a check of, you know, the design, whether you like what you see.

But I must say I'm really surprised at how little the current proposals differ from what we're doing now.

DR. GARRICK: Maybe this will stimulate them now to go back and be more daring.

(Laughter.)

MR. HEYMER: On that point, you know, we've given you today just what our very first initial thought is.

DR. APOSTOLAKIS: And I fully appreciate that. Maybe some of my comments are unfair.

MR. HEYMER: Oh, no.

DR. APOSTOLAKIS: But they're more fun that way.

MR. HEYMER: It's good input, you know? And we've got to get the input from a lot of other people in the industry, and once we've got that, you know, I'm sure we're going to have the opportunity to come back and discuss it with you again.

DR. APOSTOLAKIS: It's probably pretty much a reality, but you got the first reaction though to this.

MR. HEYMER: And really and truly, you know, if we take a look, we've often said, at the regulations at a high level, there's a lot of good

words in the existing regulation. There's also a lot of words in there that give us heart burn, and what we think is that we need to go in there and streamline and sort them out.

MR. SIEBER: I think though that part of the reason the regulations are written the way they are today is that they're supposed to be enforceable. You know, this is really the law, and when you get too fuzzy and wishy-washy about things, you can't enforce it, and if you can't enforce it, there's no point in having the regulation. You might as well just call them suggestions at that point.

MR. HEYMER: That's an idea.

DR. APOSTOLAKIS: Just a general suggestion criteria.

DR. POWERS: And there is a --

CHAIRMAN KRESS: We have a comment from back here.

DR. POWERS: -- a discrepancy in the way engineers treat quantitative views and the way the legal group treats quantitative definitions, and quite frankly, we have to accommodate them. They don't have to accommodate us.

MR. SIEBER: That's the way it goes.

DR. POWERS: Yeah.

MR. SIEBER: That's just the way the world works.

DR. POWERS: And they accommodate it by not, by avoiding the quantitative and using case law to get precision in the definitions.

MR. SIEBER: That's right.

DR. POWERS: We seek precision through numbers, and they seek it through cases and live with it.

DR. KADAK: Let me suggest -- this is Andy Kadak.

Let me suggest something a little more daring, and it's reestablishing the regulatory compact between what the regulator's job is, what the licensee's job is in terms of how they deal in terms of the future protection of public health and safety from a system that is quite prescriptive in terms of its requirements to something that more fully puts the burden on the operator to meet some what you might call high level goals.

And I'm not sure what that new relationship is, but clearly if we go to 1,000 plants, let's just say, in trying to build on George's ten times whatever the probability is and it gets to be a large number, that you can't continue doing it the

same way, and what new regime might be appropriate to protect the public health and safety in the sense of a risk informed and performance based system.

So that addresses the inspection and addresses the enforcement action, as well as the standards that you apply to new technology. So that's kind of the comment to the NEI people as well as to the rest of us, and that is how can we improve the overall process not only for design and construction and operation, but also regulation.

So a though. If there was a question on that, you can try to answer it, but it's a new regulatory paradigm.

DR. APOSTOLAKIS: But you are going the other way. I mean I get the impression from NEI that they really don't want to move too much -- to far away from the existing system. Perhaps it's the fear of the unknown.

Another Option 2 review of the times three, you know, and you are going about -- you're talking about revising the whole structure and doing all sorts of wonderful things. There must be a golden optimum in the middle somewhere there.

MR. HEYMER: Yeah. It's thinking ahead and saying, like just challenging the NRC relative to

how are they going to do license renewals for 80 plants in the next five years or ten years. They can't something has to change, some trust, some new relationship, and we have to figure out how that will work in a legal way.

DR. POWERS: Well, I mean, I think they came up with a fairly effective solution.

DR. APOSTOLAKIS: Which is?

DR. POWERS: I mean, they've gone through the catalog to a variety of data on the agent degradation, a huge number of topic reports that run four or five pilots, established a template, and people were following the template, and based on what we saw from A&O, you follow the template and you put out a pretty good product, and it goes very quickly.

DR. APOSTOLAKIS: The problem is that for licensing new concepts, we don't have a template. That's the --

DR. POWERS: Well, you're also not going to have 80 new concepts in five years. We haven't got the same problem.

CHAIRMAN KRESS: We could almost review every one of them as a special case.

DR. POWERS: I mean we do each one of the certifications in this special case because they are

special cases. Just a thought.

Now, if you had these 500 modular units, then templates work very well.

DR. APOSTOLAKIS: Then I would have a problem with the goals. The moment you get above 600, I'd have a problem with it because the goals are posed in terms of rates, and the rate inherently depends on how many of those things you have. Okay?

So if somebody says, "Boy, this is the dawn of the new nuclear era. We're going to build another 1,000 reactors," we'd have to go back to the Commission and ask them to think again about the goals they have set.

DR. POWERS: Again, they'll tell us no.

CHAIRMAN KRESS: How does the prompt fatality have anything to do with the number of plants?

DR. APOSTOLAKIS: Oh, don't ask me questions.

DR. POWERS: George, I think Tom hits upon something.

DR. APOSTOLAKIS: I think the societal risk changes.

CHAIRMAN KRESS: Of course it does, but we have no societal risk goals. That was my point.

DR. POWERS: The guy at the boundary, with few exceptions, is only susceptible to one plan.

CHAIRMAN KRESS: That's right. We need some societal risk though, which would change with the number of plants.

DR. APOSTOLAKIS: That's right.

CHAIRMAN KRESS: We don't have them.

DR. POWERS: I don't know that. It's not transparently obvious to me that you need a societal goal.

CHAIRMAN KRESS: Well, I think if you had 1,000 plants --

DR. POWERS: I think we'd be much happier if we had one to land contamination and injuries.

CHAIRMAN KRESS: Well, those goals in my mind are societal type goals.

DR. APOSTOLAKIS: Those are societal. They're societal.

CHAIRMAN KRESS: Those and total deaths I would call societal goals.

DR. APOSTOLAKIS: Yeah, yeah. Anyway, are we done with Adrian?

CHAIRMAN KRESS: Yeah. Thank you very much.

At this point I'm going to declare a 15

minute break, and then we'll start a very interesting panel discussion at four o'clock.

(Whereupon, the foregoing matter went off the record at 3:43 p.m. and went back on the record at 4:02 p.m.)

CHAIRMAN KRESS: Let's get back to order, please.

This should be very interesting. I haven't worked out any particular protocol of how to proceed with this. What I think I'll do is just say if any of you members of the panel wish to make some comments before we entertain questions, why, you're welcome to do so. You don't have to.

I don't think I like the idea of going you, you, you, you make your comments. So I'll actually open the floor. If any of you guys want to make a few comments, just go ahead and volunteer and we'll hear them and we'll through the floor open for questions while you're commenting and after you comment.

So if that's agreeable to you guys, we'll do it that way. So with that I'll say who wants to make some comments. Anybody?

Rich, go ahead and start.

MR. BARRETT: Let me just say -- is this

on? -- that in the material that we got in preparation for the workshop, I think all of us were sent questions that we were to deal with, and we were asked to make a few points about the question that reads as follows.

DR. APOSTOLAKIS: I can't hear you. Can you move the microphone closer?

MR. BARRETT: The question that we were faced with was this one. What are the most important regulatory challenges for the licensing of future nuclear power plants?

And I think the guidance we were given was that we should try to keep it to a list of three or four, and I see everyone shaking their heads that you all got the same question; is that right?

PARTICIPANTS: Yes.

PARTICIPANT: We may not have done our homework.

MR. BARRETT: All right. Well, at some point I would like to answer the question. Maybe I ought to go first and that would get everybody else thinking. How's that?

CHAIRMAN KRESS: Sounds like a good way to do it.

MR. BARRETT: Okay. Well, you know, from

the staff's point of view I think you've heard on a number of occasions how the staff defines success, and we define success whether it's in licensing or in operating reactors in terms of the four pillars that we have defined for operating reactors.

And when you're talking about the licensing of a future reactor, I think you're dealing with the same four pillars, except that you probably want to state them a little differently.

So let me simply state those four pillars. First of all, I think what we want to do is make sure that we assure safety as opposed to maintaining safety for the operating plants.

And, secondly, that we want to do that in a way that is effective and efficient.

And, thirdly, we want to do this without imposing unnecessary regulatory burden upon the applicant.

And finally, the fourth of these pillars is to do this all in a way that instills public confidence in the licensing process.

So those are the four pillars that we use for judging success of anything we do, and so keeping in mind those four pillars, I'd like to just say a few words about what I think are the most important

regulatory challenges for licensing of future nuclear power plants.

First of all, to maintain safety or to assure safety, we're going to have to take a comprehensive look at every aspect of safe design and operation, including the risk implications of these new designs.

Now, we're going to have to do that, and in order to do that, and I think this is a very important point, we must assure that the NRC has all of the requisite skills to do a complete review, and that's a big challenge for us because this is going to require a significant effort on the part of the NRC to retain our current experts and to recruit and to train new staff.

So I think that's the first thing that's required from the NRC's side.

Secondly, to assure efficiency and effectiveness, we're going to have to streamline our review of siting and licensing applications, and we're going to have to take a careful look at the time and the resources that are required for those reviews.

And I think that that's a management challenge. I think we've seen that challenge being met in the management of the license renewal

applications, and our challenge is to do that also in our management of the applications for review of future applications.

On the other hand, applicants for site permits, design certifications and combined licenses must submit complete applications of high quality. That's an absolute must if we're going to be effective and efficient, and the applicant furthermore has to assign the resources necessary to respond promptly and completely to staff questions.

So to assure effectiveness and efficiency in licensing, there's a burden on the staff, and we're prepared to go forward and meet that, but there's also a burden on the applicant to assure that you bring in that application, make a complete, high quality, and support it from start to finish.

The third bullet is avoiding unnecessary regulatory burden, and in order to do that, I think that we must bring out early resolution of a lot of the issues related to our regulatory process. In these last two days, you heard a lot of examples of these types of issues. Some of them are financial. Some of them have to do with ITAAC. Some of them have to do with the processes that we use. Some are specific to modular reactors and merchant power, and

some are bought up because we have new designs.

We're going to have to get early resolution of these questions in order to avoid unnecessary regulatory burden on applicants.

And, finally, to instill public confidence, we must assure that all of our stakeholders have access to the licensing process and input to the licensing process, and this is a commitment that has to start at the very beginning and has to be carried on throughout the process.

I think yesterday and today this workshop is a very good start along those lines. I want to point out that the staff is going to sponsor a workshop at the end of July in which we are going to be looking for stakeholder comments on a wide variety of regulatory issues that will be important as we go forward as well, and we're committed to instilling public confidence by giving people access to the process.

So those are the four areas that I think are important for licensing of future nuclear plants.

DR. WALLIS: Well, Rich, the only one comment I'd have is it's not good enough just to have access to a process. What they find there has to instill the confidence that you're trying to instill.

MR. BARRETT: Right. One of the things that we wanted to do at the workshop is very early on we want to identify where specifically, to the extent possible, where people's concerns are about the future licensing so that we can factor those concerns in at every stage along the way and make sure that we address those questions and concerns.

CHAIRMAN KRESS: I think what I'll do is after a given panelist makes his talk, I'll open the floor for questions if anybody wishes to question that particular panelist while it's fresh in your mind, and when we exhaust those questions, which we may have already, we'll move on to another, I guess, volunteer.

I don't want to put anybody on the spot, but does anybody want to speak next? Mr. Lyman, are you --

MR. LYMAN: I actually prepared slides.

CHAIRMAN KRESS: Well, that's certainly okay.

MR. LYMAN: And that's probably more than --

CHAIRMAN KRESS: No.

MR. LYMAN: -- you need, but --

CHAIRMAN KRESS: No, that's fine.

MR. LYMAN: -- I can go through them

quick.

DR. TODREAS: Don't worry because I did, too.

CHAIRMAN KRESS: That's fine. That's fine. I think that's probably a good way to do it.

MR. LYMAN: Are you going to go first?

DR. TODREAS: No, no. You spoke up first. You get the floor.

PARTICIPANT: Well, let me change these.

DR. TODREAS: Well, let me go first since she's --

CHAIRMAN KRESS: Well, since there's a palpable reason, we'll let --

DR. TODREAS: She's got the order. That's fine. Just flip it up.

CHAIRMAN KRESS: Why don't we go in the order of the agenda then? How does it read?

PARTICIPANT: That will help Jenny.

CHAIRMAN KRESS: Yeah, it'll help her. We'll do it that way. We'll go in the order that the agenda has those listed.

DR. TODREAS: I'm first.

CHAIRMAN KRESS: Okay. This is the second speaker then.

DR. TODREAS: Okay. Just go to the first

slide.

What I did since you want to constrict it, I picked out an area, which is basically fuels and materials, and actually the theme is somewhat similar to what you just mentioned. I'm going to wind up getting back to the NRC is going to have to have a confirmatory research base and is going to have to have people who know the material, can deal with material, can ask the questions.

It's going to come from the fact, and I'm building on what I did this morning, that we're dealing with fuel cycles, and I'm talking about these Generation IV plants now. I'm in the 2010 to 2030 period. I'm not talking about the near term deployment water plants based on the one through cycle, but I will get into the gas plant.

CHAIRMAN KRESS: Who should do these research, Neil?

DR. TODREAS: Well, obviously industry has got to do the research as a base, and then the NRC to a certain degree has got to do enough confirmatory research to insure that they've got a complete database for their education and to confirm to the level necessary.

We've been through, you know, a lot of

that with the research program.

DR. POWERS: But that's the rub, is knowing how much and when to do confirmatory research because, I mean, there's finite resources here, and there are constraints on the system.

DR. TODREAS: What I'm telling you is to get on fuels and materials. Make it a good part of the mix.

DR. POWERS: We never had any materials problems.

(Laughter.)

DR. TODREAS: And what I heard Chuck -- I'm glad that under number two here I mentioned coolants because we can get off into coolants, but we're going to go to longer cycles. We're going to go to higher temperatures, and since I was limited to actually two to three challenges, I just stuck four down here as a -- this is kind of an outcome.

DR. POWERS: That provokes the question: is it because you're from MIT and can't read?

(Laughter.)

DR. TODREAS: Can't count. Yeah, that's the supermarket checkout joke, but I'm only going to talk about the two that are starred, but you know, if we go to nuclear power in a significant way, we're

going to have to deal with waste volume, and we're going to have to reduce the toxicity.

I'm not really talking about accelerator trends, mutation relative to toxicity going all the way, but you've got to start to think about somehow separating out certain isotopes and going more toward the French direction of a dedicated program on volume reduction and focused on toxicity.

We're also going to have to get into coolant corrosion aspects. I never met formally Peter Ford, but I know through my colleagues he's really been into white water coolant corrosion issues, and these other coolants, no matter what we say about them, are going to have impurities in them. We're going to learn things. We're going to have to go through the whole coolant corrosion business.

But what I wanted to get to was three and four. We're going to deal with new fuels, and the first new fuel effectively that we're dealing with is particle fuel, and particle fuel for me, I can see applications not just with gas reactors, but particle fuels in different matrices can be applied in broader aspects.

So I'm very positive on potential for particle fuel, but with core loads of billions of

these particles, how are you going to deal with them?

Well, if you go to the next figure, the next figure shows my problem. What I've got here is basically a sample list of questions that I drew up about a year and a half ago and have been talking from that.

The first list, these are the types of things I'd go into relative to particle fuel. The first set of questions basically deal with the source term in terms of circulating, possible circulating activity.

The second two sets of questions are focused on whether our fuel particle is going to be qualified by a product or a process specification, and I don't know the answer to that yet, but if it's a product specification, we've got to do a hell of a lot of work because we've got to identify those attributes and those combinations of attributes that have to be controlled to certain levels, and we have to do it relative to the fuel design that we're up to.

CHAIRMAN KRESS: Are you just saying you can't know that the particle has been failed until after you stick it in the reactor and irradiate it so that you've got some signal that says you have failed particles. Is that --

DR. TODREAS: No, what I'm saying is it may be the same, but we're going to run a core filled with these particles, and we're going to say always that it can sustain a depressurization accident.

Well, what are the attributes and what's the tolerance around those attributes of particles that can be in the core that with burn-up that can sustain that transient? Ask that question and see what answers you get.

That's what you're going to have to know to go on a product spec.

If you go on a process spec, then you've got to be sure that the fuel that you're going to put in that reactor has been thoroughly enough tested, and the fuel that has been put in the reactor, how it's been fabricated is the same process that the tests were all done on on the fuel.

So that imposes or requires quite a long test program. So, say, on the pebble bed reactor, you're going to have to go back to that German fuel really to know what the process was and make sure you duplicate that process because presumably that's what the test base is on.

If you go to the third figure, I think we're moving toward a process spec, and if we do, what

I see is we have replaced or at least made the fuel fabrication facility operator analogous to the current control room operator, and you're going to really have to have the fuel fabrication facility locked into the whole operation process, which is quite different than what we do now with the product spec on light water reactor fuel.

And also, if we go to a process spec, once we freeze the process it's going to be difficult to make changes, really costly to make changes, maybe not so difficult, because every time you deal with the process, you're going to have to go back and requalify the fuel.

CHAIRMAN KRESS: This is somewhat analogous to the dilemma we face with digital INC controls where we don't determine the reliability of the product, but we control the process at which the software, for example, is put together.

DR. TODREAS: And my anecdote here is I took the relevant people to Gillette about nine months ago. Gillette has been making razor blades for 100 years. They make billions a year. They do it through a process spec.

They wrote a paper about a year, year and a half ago. They had a problem in one of the

processes. It was the washing process where they washed the blades before they put on a coating, which is the coating right on the tip of the blade that gives it hardness, the ability to cut.

And so they had a problem and they lost the process control. They didn't know why. It turned out the reason they did, being Boston, they left the soap out on the loading dock. The temperature dropped. They didn't know it froze. They pulled it out, put it in the process, and the process didn't hold.

So that's indicative of the real control and scope you've got to have if you've got a process control scheme.

The other point I want to make -- I see I'm running a little long, but the next slide.

If we go with this fuel, this long cycle, implicit with that is we're going to try to match the maintenance cycle with the operating cycle, and when we do that, we're going to really reexamine the maintenance approach, extend those aspects where we can after a good technical look. If you can't extend the interval between maintenance, you try to do it on line, and if you can't do it on line, you try to change the practice by design and bringing in new

component design, new systems.

And I've basically got an example of relief valve testing that we've developed associated with IRIS because IRIS would try to go to a long cycle, and relief valve testing, very difficult now to do it on line. It's going to have to go through a code case, but we've come up with a relief valve system that I think could possibly do it.

But the point I wanted to make when you can finally come down to adjustments in the practice.

So finally, last slide. Why are these items challenges? And then I come back to the point that was made. In the fuels and materials and coolant corrosion area, you're going to need to develop the NRC staff expertise. Develop it, hold it. The real strength of this place is that smart people can ask the right questions, and we really get off base if people don't ask the right questions in terms of getting technically focused on what's important, and you need this confirmatory research base.

And then finally, the last bullet at the bottom just goes back to what we talked about on this risk based regulatory framework, and I really look forward to NEI picking that ball up, leading, and giving us something relative to these new reactors

because we're going to have new coolants, new systems, new fuels, and we're going to have to take advantage -- I look at that -- take advantage of the opportunities when we go to new systems to open this up.

But you guys are going to have to take the lead with a structure that goes through these guys and satisfies them and has a good dialogue.

CHAIRMAN KRESS: Thank you.

Questions? Comments?

DR. GARRICK: One of the things that bothers me about these challenges is the resource base, the talent, because we are talking about fuels quite different from anything we have been dealing with. We're talking about thermodynamic conditions quite different than anything we've been dealing with very seriously.

The government is not known for its ability to change people in and out efficiently and effectively, and yet the whole regulatory process is founded on technical expertise because it can't be automated, except up to a certain point.

So isn't that a real problem in coming to grips with these new technologies?

DR. TODREAS: Well, that's why I raised

it, because I'm hopeful that the ACRS will find reverberations through it, but I mean, that hasn't gone unrecognized at all in this building. I'm just looking behind Graham Wallis and Ken Rogers is there. When I was involved with the research oversight, that was one of the whole points that he raised, the competence or the requirement to maintain and enhance the competence of NRC.

I don't exactly know where it's gone over the last two or three years and whether it's a problem, but I know in fuels, fuels in particular, we got so much -- you know, we weren't pushing the burn-ups very much. We had a fixed fuel system. There weren't many issues in the research side. The number of people really knowledgeable and working in fuels was reduced just because there wasn't a demand.

Now not only are we pushing light water reactor fuels up, but we're going to bring in SURMETS, METMETS, et cetera.

DR. POWERS: Let me take a devil's advocate position on that and just reason a little bit from analogy.

DR. TODREAS: Go ahead.

DR. POWERS: When we look at reactivity excursion accidents in the current generation of

plants, we typically find them to be a very localized phenomenon. It's fairly challenging, in fact, to imagine any of the probable reactivity excursion events like a control rod ejection.

And when I say "probable," something greater than ten to the minus sixth, say, probability leading to a core-wide event that results in any public hazard.

When I look at these modern reactors, maybe there are more adventurous things, but by and large, I would say reactivity events are going to be relatively small sorts of things compared to loss of coolant, loss of heat sync accident.

I guess I'm asking the question: why should we get involved in fuel? Why don't we just let that be the licensee's problem? He's the one that's got to take care of his work force. He's the one that's got to take care of this plant and his fuel and really draw our boundary and say what we're really interested in is fission product release that goes outside the plant.

DR. TODREAS: Yeah, but don't just start off with reactivity accidents. Start off with operational reactor behavior and failed fuel and --

DR. POWERS: Let that be his problem.

Coolant activities, start-up problems, things like that, it doesn't impact the public health and safety. So let him worry about that for his purposes.

DR. TODREAS: Okay. The only answer to that when you come back, that is his problem. Fundamentally the licensee is responsible. He's responsible for everything, but if you've got a regulatory agency or you're got a development agency in DOE, the best regulator and the best developer in DOE is a smart customer because they don't waste your time on putting you on the wrong questions, and they don't waste dollars going out and developing the wrong data.

So it's just a question that I have the belief that government ought to have the best people they can, and they need competence to interact with the guy who owns the problem.

DR. APOSTOLAKIS: I also think, Dana, as you know very well, if we start regulating that way, we're not satisfying or meeting the fourth pillar that Rich Barrett mentioned, public confidence. If you start having incidents that affect the core but do not end up releasing anything, I don't think the public is going to trust us very much, and that's why you have the cornerstones in the oversight process that include

initiating events.

I mean you can argue there it's none of our business as long as there is no core damage or as long as there is no release, it's not our business, and yet the agency says, no, it is our business.

DR. POWERS: And what I'm saying is why. You're saying it's a public confidence issue?

DR. APOSTOLAKIS: Yeah, it's a public confidence issue.

CHAIRMAN KRESS: I would think there's a strong reason than that.

DR. APOSTOLAKIS: I don't think it's weak.

CHAIRMAN KRESS: I would think there's a stronger reason than that, Dana, and that is you want to -- one of the principal performance indicators, for example, is that you want them to be something that tells you that things are wrong, but they're not approaching a catastrophic condition yet, and then similarly, if you put the regulations here, you want to regulate to a level that, for example, radioactivity in the primary system, if it's a gas cool.

You want to say, okay, this is indicative of some level of failed fuel, and even though if I release that, it may not hurt the public, but I'm not

sure that if I ever undergo an depressurization accident it may not have something equivalent to the iodine spike, and it may be too much. Maybe I should regulate to some level that's short of hurting the public if it gets release.

That would be my --

DR. POWERS: I mean, I can -- all right. Suppose you came along and said, "Okay. You run your -- just make sure you coolant level is such that you never come within ten percent of the 10 CFR 100 limits."

CHAIRMAN KRESS: I would buy that if they also included some factor of safety to take care of the spike like concept.

DR. POWERS: The fact of the matter is we've never found any relationship between coolant activity and risk to the public health and safety.

CHAIRMAN KRESS: But you might if you didn't have a containment.

PARTICIPANT: Exactly.

DR. POWERS: We'll always have a containment.

CHAIRMAN KRESS: Oh, okay.

DR. POWERS: Remember Moses with the 11th Commandment?

CHAIRMAN KRESS: Yeah.

DR. APOSTOLAKIS: This is not a Committee position. This is a personal view.

MR. HOCKRITTER: I was going to ask Neil something, but let me just also respond to Dana.

I was going to say the same thing. Some of these designs are looking at not having a containment, and then I think you have issues.

Today in the light water area, really failed fuel is a utility or an operator concern, and it's a vendor concern, and you're very, very careful about it because obviously if you want to sell fuel, you don't want it to fail. So it's a problem that solves itself.

But you've got a containment around the plant. In some of these designs you don't have a containment, and I think it could be more of a problem.

DR. POWERS: Made an awful good argument for having a containment, didn't you?

MR. HOCKRITTER: Back to Neil, on your process control, are you envisioning a control process where you can try to control each, on these particles, each layer in this thickness within a specified amount or the total product as it comes out?

Because I don't see how you control each layer, and if you control on the total product that comes out, if it doesn't come out right, and you won't find that out probably until you operate, then you've got a problem.

DR. TODREAS: Okay. First, let me answer I'm not promoting either a process or a product. What I am doing is asking whether it is going to be a process or a product, and then developing a line of questioning along each.

MR. HOCKRITTER: Either way.

DR. TODREAS: However, now, in addition though the way you ask the words, a process spec means that you control the process of every manufacturing step. So you may have a process where you're doing the coating, but you don't go and measure the coating or sample the coating. What you do is you control the attributes of the fabrication process.

MR. HOCKRITTER: Well, how do you know you meet your criteria if you don't go and measure?

DR. TODREAS: No, no, because what you do in the qualification stage, you take the product that comes out; you put it in the reactor; and you'd better make damn well sure it can take the burn-up with a failure criteria over whatever your design length is.

MR. HOCKRITTER: Yeah, but at some point you're going to have to have gone through and verified that whatever your process is gave you the product that you wanted.

DR. TODREAS: Absolutely.

DR. APOSTOLAKIS: There is indication or evidence that the process is working well. That's different from having a product based method for testing.

And it's the same thing with software as Tom said. I mean we are largely controlling the process now, but then we know if we're going to put it there in the field and it starts failing that something was wrong with the process.

DR. TODREAS: Larry, there's a tremendous amount of radiation data on this particle fuel. If you can pin down the process that it was made to and link it to the data, then you can say you identified the process, and then you can basically duplicate it and keep going. That's the burden the applicant is going to have.

DR. APOSTOLAKIS: Yeah, I agree with you it's late, but it's not a matter of choice really, process versus product. You're forced to go to the process because you don't have the tools to do the

other one. So it's -- you know.

DR. TODREAS: Why do you say you don't have the tools?

DR. APOSTOLAKIS: Well, take INC, for example. They know a little better than fuels. Right now nobody knows what kinds of tests you should do to a new digital system to assure that they will perform out there. So it's a combination of controlling the process of producing the software, and of course, you do some tests, as well. But this envelope --

DR. TODREAS: Okay. I might not be surprised if an applicant comes in and says, "I know what the thickness of the various layers have got to be within a certain spec. I know what the impurity levels are that need to be controlled."

You may be a case on fuel that way.

PARTICIPANT: You're going to need that to get an analysis. You're going to need that information to do the analysis.

DR. TODREAS: What was asked for is the challenge.

DR. APOSTOLAKIS: Right, right.

DR. TODREAS: Okay? That area is --

DR. APOSTOLAKIS: It is certainly a challenge.

(Laughter.)

CHAIRMAN KRESS: Okay. With that, let's move on to the next speaker, which according to the list here would be Mr. Lyman. Are you prepared or are you over there tying your shoe or what?

MR. LYMAN: No, I was looking for more evidence to demonstrate the previous discussion.

CHAIRMAN KRESS: You're welcome to go ahead and look.

MR. LYMAN: No, that's okay.

DR. POWERS: I'll pull out. I see you guys can't see directly.

CHAIRMAN KRESS: Okay.

MR. LYMAN: Actually, like Bill Magwood yesterday, I'm not quite sure what's in these viewgraphs, but unlike him, I did write them myself.

(Laughter.)

MR. LYMAN: I think it's interesting that the fuel issue has come up because I definitely had that on my list as one of the challenges, and I'll go into that in more detail.

Can I have the next slide, please?

I think the overarching context, I'm the first member of the public and not the industry or DOE or NSC to address this workshop. So I am going to

speak generally as a member of the public.

I see the fundamental dilemma of nuclear power expansion right now is that without massive subsidy, there are not going to be any nuclear plants built unless they can really compete with cheaper fossil fuel sources, and that means perhaps mimicking these characteristics like low capital costs, short construction time, modularities of distribution that we've all heard about, and the question is: are these really appropriate criteria for nuclear power plants or is there something fundamental about nuclear technology which will make that difficult?

Can I have the next slide, please?

DR. POWERS: Well, let me go into just a question of philosophy a little bit with you here. Since, I guess, some time in the early '50s, the government has felt some sense that it should foster a peaceful use of atomic power, and is there any reason that that general government feeling should be viewed as having changed?

MR. LYMAN: Well, in my view there's been enormous public support of nuclear technology here and all over the world since the dawn of the Nuclear Age. I forget what the exact figure is, but it's certainly in the -- if you include fusion, it's in the hundreds

of billions of dollars at least.

And the question is maybe it's time for the government to stop weaning nuclear power and let it go out on its own and see if it can compete.DR. POWERS: Well, I mean, that's a decision we leave to the politicians to make. I guess I'm asking have they made that decision.

MR. LYMAN: Well, if you look at the Bush policy, you'd have to say no sine it seems to suggest rekindling a large domestic nuclear research program and does make reference to technologies which right now are uneconomic likely processing or accelerated transmutation, which would require large government subsidy to actually complete R&D development of this system.

So if you take that policy on its face, there may be a change at least in the administration's thinking. I'm not sure they appreciated that when they put out the document because I understand they were stung by some of the criticism by conservative think tanks of what looked like an endorsement of government picking winners and losers.

CHAIRMAN KRESS: That's a sign, I think, of a low battery in there. Have you guys got it? Okay.

Pardon me for interrupting you.

DR. POWERS: Okay. I mean, so right now the inherent assumption in your first bullet is not necessarily one that has to be made.

MR. LYMAN: Well, I'm saying in the absence of a policy decision that the public and taxpayers do not support subsidization of construction in nuclear power plants, then the rest follows. If they are, and if that's a decision in the public, then it's a different ball game.

DR. GARRICK: Would you accept as a substitute for those three items, low capital cost, short constructions time, modularity, and ease of distribution low power costs? I mean, why would you pick on a component of something that's much more relevant?

MR. LYMAN: Well, because these are the features as distinguished from going to larger and larger reactors, which is the other way to reduce power costs through economies of scale.

At least some of the feeling as a member of the public reading literature, that there is this feeling in the nuclear industry that by imitating these characteristics, that is the best way to benefit from the favorable economics of gas turbines.

There's no more market for large, you know, very large base load plants, and especially if you consider the export market to less developed areas of the world.

You know, this isn't my own conclusion, but this is what I've heard. If you can come up with another way of doing it, cutting costs, fine, and we just heard the gentleman from Westinghouse emphasizing reduction of capital costs and payback time is so important.

DR. GARRICK: Yeah. Well, I think the alternative is power cost because I think that's what the public wants.

DR. POWERS: Well, I think you've got an inherent schizophrenia here on the arguments. You've got arguments that get advanced to us that say, "My God, there's a crisis. We're going to need tens of thousands of additional kilowatts," and at the same time we've got to keep the costs very low.

The two don't match. There's a crisis. We'll pay what it takes to get the kilowatts.

DR. APOSTOLAKIS: But the subject of the workshop is regulatory challenges, not national policy regarding nuclear power. So perhaps we can -- if we want to finish tonight.

(Laughter.)

MR. LYMAN: But there is a link actually because part of the new driver for accelerated licensing new plant designs is this perceived crisis. So they're really linked, and one of my concerns as a member of the public is that there's going to be momentum toward expediting, streamlining, licensing of nuclear plants without the kind of deliberation that I think was probably necessary for the previous designs.

Can I have the next slide?

So the challenge is given these advanced designs that have the features that I described on the previous page, how do you maintain issues like without having a negative impact on safety, on risk of radiological sabotage on waste management, on nonproliferation, and on opportunity for public participation. So these are some of the top level challenges, and I talk about a few of them.

Next slide, please.

Okay. So the example I'll fix on is a PBMR, not because I want to pick on it necessarily, but it is what's coming down the pike, and there's more detailed information about the approach that developers want to take.

DR. APOSTOLAKIS: I think you're going to be more comfortable with this, Lyman.

MR. LYMAN: Right.

DR. APOSTOLAKIS: Where you don't have to come back and forth.

MR. LYMAN: But I want to see you, too.

DR. APOSTOLAKIS: Oh, okay.

(Laughter.)

MR. LYMAN: So the PBMR, you know, we've heard a lot about it. So it's something everyone understands, but there are fundamental characteristics which are at odds with conventional balances, defense in depth elements like the lack of a pressure containment, significant reduction and safety related SSCs, a proposed reduction in the emergency planning zone radius by a factor of 40, and a greatly increased reliance on fuel integrity to compensate for mitigated measures to protect public health.

And going back, this is not a new reactor and neither are any of these issues, and in fact, neither is the discussion because you go back to the mid and late '80s, you find the ACRS has already commented extensively, and I think they wisely stated in 1988 that it would require unusually persuasive arguments to justify what they characterized as a

major safety tradeoff.

In other words, emphasis on preventive rather than mitigative measures.

Next slide, please.

And so with the PBMR, I agree with Professor Todreas that fuel performance is the big challenge, and when I started looking at the data after hearing the pitches made by the PBMR promoters about how this is meltdown proof fuel, how it's indestructible, how you have to heat it to 2,200 degrees Celsius to get the fuel to melt, well, it turns out, of course, that the data that's been accumulated is a lot spottier than that, a lot less definitive, and the first interesting thing about the data for pebble bed fuels, they really don't understand its performance in relation to changes in the initial conditions.

And until that understanding is acquired, it's going to be very hard to implement the kind of process or product controls that we just heard about with confidence.

Also, the robustness of this fuel is being widely oversold right now, and you do not have to get to the temperature where there's fuel degradation to have significant fission product diffusion through the

silicone carbide barrier.

And could we have the first, the one with just one graph on it? Thanks.

Okay. So I started looking at the data, and this is not the kind of pretty picture we saw yesterday, and like someone just told me, anyone who knows anything about pebble bed or gas cold reactor fuel is aware of this data, but how come we didn't see it in the last two days?

So I'm going to show it to you. This is a summary of German data. Sorry it's so out of focus. This is actual fission product of Cesium 137 release from TRISO, from actual graphite pebbles with TRISO fuel in them, and there are a variety of different burn-ups here, but it gives you the flavor.

This band is 1,600 degrees. This is release fraction versus heating time, and you can't really read it, but the upper band is 1,800 degrees, and you see that you get into quantitative cesium release on the order of several to ten percent after 50 to 100 hours of heating time at 1,800 degrees.

Can we have the next slide, please? The next graph.

And this is substantiated by recent Japanese data. This is from a journal last year.

Also TRISO fuel irradiating the Japanese gas cooled reactor, and you see you have the same behavior roughly after 50, 75 hours of heating time. You get a rapid increase in fractional release of cesium up until about ten percent, and this is 1,700 degrees. That's 1,800. You see you go almost to 100 percent on silver. You go beyond ten percent at 1,800.

Can we have the next -- actually the previous computer slide, please, no, the Power Point slide.

Okay. So, you know, here's the gritty reality about pebble bed fuel, is that the margin to significant cesium release is not nearly as great as it is to massive fuel degradation. So I'd like to hear less about how the fuel is meltdown proof and more about how the cesium releases are going to be mitigated in the event of, let's say, a 100 degree over shoot in the predicated maximum temperature after depressurization.

Now, so clearly quality control is paramount since we're being told that the fuel is the containment in this case, and that raises the issues about British Nuclear Fuels involvement as one of the designers of the South African -- of the SCOM pebble bed fuel manufacturing facility.

And just for a little background, BNFL almost single handedly killed the Japanese nuclear industry by exporting mixed oxide fuel to Japan that had fabricated quality control data, and the reason why the quality control data was fabricated was because the people who were working on the production line got so bored with doing manual checks on this fuel they decided they're rather just copy sheets of data, you know, whole bore.

And i think it affects the credibility of BNFL, as well as raises general issues about how reliable, how much emphasis you can put on fuel reliability and quality control in affirming reactor safety, and that's why I would throw out that the fabrication plant really is part of the reactor system and, therefore, there's going to have to be greater involvement in fuel fabrication by NRC even if it's done overseas, I think, than is customarily the case, according to Appendix B criteria.

And so I'd suggest that there has to be an ITAAC on quality assurance for fuel manufacture in this case, a programmatic ITAAC.

Next slide, please.

MR. SIEBER: Maybe I could interrupt. The first graph that you put up, could you tell me where

it came from?

MR. LYMAN: Yeah.

MR. SIEBER: I want to read the whole article.

MR. LYMAN: From the reference that's in IEA Tech. Doc. on fuel, pebble bed or gas cooled reactor performance, and I don't think I have the number with me, but I'll get it to you afterwards. It's within the last three years or so.

MR. SIEBER: Okay.

MR. LYMAN: It may be 978, but I'll have to check.

Okay. So --

DR. POWERS: I think I can find it for you, Jack.

MR. SIEBER: Thank you.

MR. LYMAN: Now, on the issue of safety goals, which we've heard something about, I think that the safety goals do need to be reexamined for advanced reactors, and I don't think the current goals are conservative enough.

And a little thought experiment is that if you actually remove the containments from most light water reactors operating today, would they still meet the safety goals? I think at least according to the

existing calculations, they would, and that's because anyone in the industry will tell you they were already a factor of ten or more below the safety goals in existing plants.

And since containment performance is predicated on a ten percent -- less than ten percent conditional containment filler probability, I think this is an example of why the existing safety goals should not be the target for advanced plants.

We also need to define --

DR. APOSTOLAKIS: Excuse me. I think this is going to be challenged a little bit. You are evaluating the usefulness of the goals by going through the plant and say, "Well, gee, the plant is really much better than the goal. Therefore, the goal is not conservative enough."

I can pick the other line and say, "Well, gee, the goal will be set independently of the plant by using some societal measure. So one tenth of one percent of other risks, I don't know that that's not conservative.

MR. LYMAN: I agree, but I'm not sure that's the history of the development of those goals. I mean, it is kind of convenient that they were chosen at a level where the fleet of plants does meet them

with a large margin. Maybe it's just a suspicion, but you know, that number was picked out of a hat as far as I can tell.

Okay, but fair enough.

DR. WALLIS: But you could remove the statement "not conservative enough." It might still be valid to say that the goals could be met with containments removed, if that's a true statement.

That's an interesting statement to make.

MR. LYMAN: Well, if that is true, it makes one think. I'm not, of course, recommending that.

DR. APOSTOLAKIS: That was my next question.

(Laughter.)

MR. LYMAN: No, I'm not recommending it. I'm just wondering if the existing safety goals do capture what needs to be captured in the public concept of reactor safety.

And in the industry in the West, it really dug its own hole in this regard. After Chernobyl, the chief response from the Western nuclear industry is that can't happen here because our plants have containments.

So you have to think a little bit about

how the public response is going to be when you try to introduce graphite moderated reactors in the containments in this country.

One issue is what do you do with the concept of a large early release, especially if you have a reduced evacuation zone. I think you need to think in terms of a large release in the case of the pebble bed. Since there's going to be a large number of people who no longer have instructions to evacuate, and given the type of cesium releases that I think the fuel is capable of, this is something that also I'd like to think about.

CHAIRMAN KRESS: If you're not going to have evaluation, the E ought to go out of the ERF.

MR. LYMAN: Right. There's no meaning to "early" anymore.

CHAIRMAN KRESS: Yeah.

MR. LYMAN: And since a lot of these released don't occur until 50 hours into the accident, then, you know, that also has to be figured into it.

And so one issue, you know, is is it going to be necessary to add additional requirements to the pebble bed to make it safe enough, and the IEA pointed out or it was actually an IEA document where I saw the statement that if a whole lot of additional

requirements had to be imposed, it would really threaten its economic viability.

Yet there are some characteristics we're thinking about. One is the fact that there is no secondary coolant loop in the SCOM design. Yet the MIT design proposed by Kadak does have one for the reason that it reduces the risk of water ingress.

So the SCOM design isn't the last word in the pebble bed, and there has been discussion apparently in the literature about coatings which are better or more refractory in silicon carbide than zirconium carbide, and maybe the whole issue of whether the fuel, the traditional TRISO fuel is suitable.

These all have to be opened up, and I don't think in the schedule that's been laid out there's going to be enough time to do that.

Next slide, please.

My next major concern is the issue of radiological sabotage, which I think could be a show stopper for certain features of advanced plants that have been suggested.

Just to beat a dead horse, 50 percent of U.S. nuclear plants today have failed their OSRE exercises, meaning that mock terrorists can simulate

enough damage to cause the core in a force/unforce simulated attack.

Exelon's Quad Cities was an example of a failure in early 2000. To quote from the inspection report, deficiencies in the licensee's protective strategy enabled the mock adversaries to challenge the ability to maintain core cooling containment.

So I'd like to see Exelon concentrate a little more on defending their existing fleet of plants before starting to site new ones.

Next slide, please.

And the basic point here is that no matter how inherently safe a plant is from accidents, there's always going to be a scenario, I believe, that someone clever enough can cause fuel damage, and this was touched on actually in this morning's discussion.

And that means to me that you're not going to be able to justify drastic reductions in the security force requirements for pebble beds, and also that the issue of additional defense in depth measures like containment may be warranted for that reason even if probabilistically they're not warranted from an accident standpoint.

And, third, plants that have in situ reprocessing modules like the PRISM we heard about are

going to be unusually attractive because you already have fuel that's in process in a disbursable form.

It turns out that the very wise ACRS in 1988 recommended that sabotage resistance be a design feature, general design requirement for advanced plants, and I don't think I see that in the current generation that's been proposed. In needs to be thought about, and there needs to be involvement now with the NRC safeguard staff in trying to challenge the pebble bed from the point of view of sabotage.

Next slide, please.

Waste disposal is the third challenge. Obviously the issue of waste disposal is going to be a driver in whether we can sustain an expansion nuclear power in this country, and the other issue that the pebble bed people don't like to talk about is their waste. And rather than minimize waste as was one of the Generation IV requirements, the pebble bed generates a volume of waste, ten times as much, something I verified myself by calculation, meaning that storage and transport requirements per kilowatt hour generated are going to be ten times greater, and you'll need ten times as many packages in a repository if you ever get to that point.

Thinking about the problems that are

already going to be encountered in transport, it seems that ten times as many shipments from the same amount of electricity might raise a red flag.

The other issue is Carbon 14, specially in the context of the repository. You're going to get quite a lot more Carbon 14 in a gas cooled reactor design, and because of gaseous emissions, the gaseous emission issue in an unsaturated repository, that could be a dose problem.

Next slide, please.

So just from a public acceptance standpoint, getting back to my original point, I think that a better approach for new plants, if the industry really wants public acceptance, is not to try to cut margin where it can, even if it claims it has a safer design.

The goal should be to increase safety, the next step, and that would in my mind suggest a limited number of sites that are well protected rather than small scale reactors which are widely disbursed, and might require gold plating instead of trying to shave margin where you can find it, and that approach would be inconsistent with these performance based tendencies that we've heard about earlier today.

Next slide, please.

And the aggressive licensing schedules that have been proposed, I think, are also going to aggravate and generate public opposition, and it's really better to proceed cautiously to make sure there's full resolution instead of trying to expedite and streamline.

That's all. Thanks.

CHAIRMAN KRESS: Questions or comments?

MR. SIEBER: Do we have copies of these slides?

DR. POWERS: Did you want to say anything about resistance in connection with the PBMR?

MR. LYMAN: Well, there are two issues. One is the fact that it's on line fuel, which I think will increase the safeguards' inspection requirements. Of course, it's not an issue in the U.S. since we don't -- you know, we have voluntary safeguards at nuclear plants, but overseas it could be a problem.

It's going to take more work to inspect, you know, system discharges. What is it? Tens of thousands of balls a year, I think, or more as opposed to a system where you only have to be present, an inspector only has to be present once every year and a half or two years to observe core loading.

Now, the tradeoff is that the fuel is

quite dilute. It would take a lot of it, as we heard this morning, to divert a significant quantity of plutonium.

But, on the other hand, if you have a large utility that operates a large number of these plants, if let's say there were some malevolent desire on the part of the operating company to divert small numbers of fuel from each one of these modules, then you could have protracted diversion as an issue.

So the safeguards requirements are really going to require some evaluation.

DR. GARRICK: There is one part of your message that I like very much, and I think the NRC is quite sensitive to it, and that is that the industry has to be very cautious about overselling the PBMR, for example. That kind of activity has been a result in the past and has been an example of the industry shooting itself in the foot.

And I would agree that there seems to be a wave of confidence and enthusiasm towards the concept that from a scientific and technical standpoint certainly has not been demonstrated on any kind of systematic, evidentiary basis at least yet.

So I think that's a good comment.

DR. TODREAS: Can I make just two comments

on things that you mentioned?

I was not here yesterday and, therefore, don't know exactly what you've heard, but my understanding on two points is the following.

On the secondary system difference, my understanding is that Kadak has gone to the secondary system because of development times and requirements on the helium power cycle. He has not gone there because of a feeling that water ingress is a problem that can't be beat on a direct cycle.

So I would suggest you discuss that further with him on that.

And, second, on the depressurization transient and the temperature that the fuel is allowed to go to, I thought 1,800 or even less was the maximum limit that it had always been designed to.

I got the implication from what you put up that the target was up at 2,000 or so.

MR. LYMAN: No. I mean, I don't know what the target actually is, what the number that's used, you know. When Exelon or whoever is presenting this data to the public, they use the figure 2,000. It appears in a whole lot of literature, and so that gives the impression that there's a bigger margin than there may actually be to fission product release.

That's my only point.

DR. TODREAS: If the number 2000 is being used, but the design calculations and the criteria from analysis on the depressurization, at least in the context I'm familiar with, has always been lower than that. Eighteen hundred may be a little bit lower, but since I don't remember exactly, I don't want to say lower.

Larry?

MR. HOCKRITTER: I was going to say I think it's around 1,600 C.

DR. TODREAS: Yeah, okay. I've got 1,600 to 1,800. I wasn't sure of the exact number.

MR. SIEBER: He said 1,600.

DR. TODREAS: But the point is that number encompasses some awareness of -- I think a great deal of awareness -- of the data that you show. So I think you might take some comfort and actually talk to the analysts about that.

MR. LYMAN: But, you know, one needs to see what the uncertainty is in these calculations and what the actual error bars are and the maximum temperature. What are the factors that could conceivably cause the final temperature to be increased?

You know, that's the kind of systematic thing that hasn't been presented to the public yet, and my concern is, you know, the numerous articles, and there's an enormous amount of press interest in this reactor, but the claim is it's meltdown proof no matter what happens to it. You can't get radioactivity out of it, so you don't need a containment, et cetera.

And I think that kind of talk is inappropriate.

DR. WALLIS: I think there ought to be more reassuring. If Exelon had presented the kind of curves that you presented and the worst curve which they presented was one which was not on a log scale; so everything sort of disappeared down to the reactors, then appeared to come up at 2,000.

That doesn't tell you anything about this kind of stuff that you presented.

MR. LYMAN: Right.

DR. WALLIS: So it may well be that the scheme is all right. It's just that it will be more convincing to the technical community. They presented this stuff, and we didn't have to hear it from you, and I think that's a good point.

CHAIRMAN KRESS: All right. Why don't we

move on to the next speaker, which according to my list is you, Ron Simard. You're welcome to make any sort of presentation that you wish.

MR. SIMARD: No slides. Just a comment.

My focus would be on the near term challenges facing NRC, and I go back to my presentation of this morning, but I would very strongly endorse what Rich Barrett said.

I think we need to keep in mind this fact that the credibility of the regulator and the process is essential to the industry to be able to meet our objectives. So I would roger everything that Rich said -- Roger Rich -- I would roger, Rich, everything that you said.

With respect to the need for a tangible and clear demonstration of safety, involvement of the public, I would certainly pick up on your suggestion that we do need this early resolution of some of the open issues because as I said this morning, the potential licensees of the future are looking for much more certainty and knowledge of the licensing costs and schedules than they've had in the past.

And certainly I would roger his points on efficiency. With respect to the work force, one of the things that we're doing in terms of trying to

assure that we have the work force we need for the future is we're working with this group of young professionals now called Young Generation North America, and the definition of young in this case is 35 years old.

And as Rich was talking about the importance of the work force to the NRC, I looked around the room at some of the NRC staff in the room, and I wouldn't ask for a show of hands, but look around and you guess how many of the NRC staff in this room would be eligible to join the Young Generation.

So I would certainly agree that there is a challenge to the NRC in terms of maintaining not only the number of people, but the level of skills. I think Dr. Garrick mentioned the level of skills and so forth, but I think one of the points I see us keep returning to in the last couple of days is the importance of this risk informed approach to meeting some of these objectives that we've been talking about, for example, being able to demonstrate to the public what is significant in terms of safety and being able to assure the NRC, the licensees and the public that we are, in fact, focusing our attention on what is significant.

We've heard a lot of discussion about the

need to draw even more on some of the successes we've had so far in implementing this risk informed approach and being able to take advantage of the new insights we've gained.

But I would suggest that maybe one of the biggest challenges of all is the culture change that the NRC is going to have to implement to be able to get acceptance of that across the agency at the levels that are going to be needed to handle the licensing challenges in the near future.

And that comes from the top. That requires leadership.

CHAIRMAN KRESS: Why don't we move on to Ms. Hauter? You're the anchor today.

MS. HAUTER: Well, I always enjoy coming to the NRC to meetings because I never have to wait in the ladies room.

(Laughter.)

MS. HAUTER: And I hope that I'm not going to add to any gender stereotyping, but I don't have a Power Point presentation, and I didn't get the questions beforehand. I've based my comments on what I've heard at this meeting.

And I don't think that I would have used a Power Point presentation anyway because I think it's

my role as coming from public citizen to speak plainly as a member of the public.

So even if you don't like what I have to say, I promise there will be no techno. talk, no incomprehensible jargon, and no indecipherable acronyms.

PARTICIPANT: Thank you.

MS. HAUTER: We've heard a very rosy picture painted this morning. I think that it was Ron who talked about the poll in California, that public now supports nuclear power, and I'd like to say that we've done a lot of polling, been involved in a lot of polling through the years, and that the public always supports renewable energy and energy efficiency first, and that that is a very deep support.

And in fact, the Post had an article today showing that President Bush is losing support, and that 58 percent of the American public now disapprove of his energy plan.

So I think that when the numbers of nuclear power plants go in two days from 200 to 1,000, that that's your biggest challenge, is when you're talking about these large numbers, and you have almost no public participation in a meeting like this, that our telephone is beginning to ring off the hook, and

you're helping us mobilize a new anti-nuclear movement.

So, you know, I would consider that in these kind of large promises that are being made.

Now, I think that we all know that through the years, that the cooperation of the industry and the agency has led to a weakening of the democratic process both of licensing and siting new plants, and I suspect that people in the room feel that that will certainly help this new generation of plants, but I think the biggest challenge is going to be about some of the issues that Ed spoke of, especially the issues of subsidies.

As I sat here throughout this meeting, I heard a lot of words that really mean taxpayer money. Let's see. We heard cost sharing, government R&D, talk about the Price-Anderson Act or even the license by test with the government picking up the cost for the test facility and the liability.

And you have to have political support to get that kind of level of subsidies, especially for the number of years that you're talking about, and I think that it's a real problem when at the same time we hear an analysis of the electric industry in 24 states have deregulated and we hear that we've now

moved into this deregulated, competitive marketplace, and we could argue about whether that is true or not, and I would say that it's not true, but that is certainly what the public is hearing.

And we also know that the reason that nuclear power is so cheap now in these deregulated markets is that O&M is cheap because of the huge bail-out that's occurred at the nuclear industry, over $200 million for all of the stranded costs, and so basically the mortgage has been taken care of, and that's why the issue of capital cost is so very, very important.

But this puts you in a very vulnerable position because, on the one hand, people are talking about this competitive market, and on the other hand, this plan that you've laid out is going to take massive subsidies, and we're going to see a fight over the reauthorization of Price-Anderson.

Now, I recently had a very interesting speaking engagement, and I probably won't be asked back to speak at this for a number of these gatherings either. It was the Institute for Infrastructure Finance, and I'd never heard of this organization. I had to look it up on the Internet.

It's a group of, an association of the

financial institutions that build power plants and water projects and so forth. And I sat through two days of this meeting. In the last session I debated somebody from Cato about energy policy.

The whole tone of the meeting was getting the public to accept paying higher power costs, but these investors expect to get a 35 percent rate of return on profit after just a couple of years of investment. They're going to get in and get out quickly. I mean it was enormous profits that they were talking about.

And I asked a number of the bankers and investment institution representatives there in conversations and publicly whether they were going to invest in nuclear power, and not one person said that they were. In fact, I was laughed at.

So I think that there are some major challenges around subsidies and costs.

The third point that I'd like to make is that the theme of this meeting has been how to further deregulate the regulatory authority of the NRC, and I'll have to tell you I am always appalled when I hear things like the regulatory process described as a negotiation because negotiations take place between partners of equal power and ability, and in my mind,

regulation, especially what the NRC is supposed to do, is a government function with the goal of protecting the public's health and safety, not protecting the profits of the nuclear industry or the future of the nuclear industry.

So the idea that the mission -- and I know that this negotiation talk has been going on for some time -- but it just to me demonstrates the abysmal state of regulation, and unfortunately, I think the truth is closer to has become a negotiation process, and that's because of our political situation and our system that we believe is a system of legalized bribery, where public policy is led by campaign contributions and lobbying.

And we believe that the Nuclear Energy Institute and their ability to give campaign contributions and to influence Congress has grown significantly.

Now, whether this will continue and we'll be able to get the amount of subsidization that is required, we don't know, but I think that all of this conversation that's taken place here has taken place without any political context, and that that's another thing that's very disturbing to me, is that there are a number of other things going on politically besides

this new generation of plants, and I'd like to just mention a couple of them because I think they all play into the health and safety concerns that we have.

One thing is IAEA's attempt to harmonize radiation standards across the world and to increase the amount of radiation that the public can be exposed to.

The other is the National Academy of Sciences' BEER 7 (phonetic) Committee, which we believe the deck has been stacked with scientists who support exposing the public to higher levels of radiation.

There are the DOE studies that are going on, the radiation studies, which we don't believe will be done fairly.

And then there's the NRC's process to deregulate a category of low level nuclear waste.

So the thrust of all of this is that the public can and should be exposed to more radiation, and then when I come to a meeting about a new generation of plants, and I hear almost no real discussion of how many radiation releases, what the amount of the radiation releases are, and it's all really shrouded in technical talk and not real talk that people can understand, I think that that's a real

concern.

My next point is related to the political context, and that's the discussion of regulation, and I think most of the presentations here talking about licensing and so forth used code words for deregulation, and we're concerned about the deregulation of safety records. I'm concerned when I hear jokes being made and the ACRS Committee suggesting that NEI isn't going far enough in rewriting regulations, even though I believe that was tongue in cheek.

And I think that we've heard a lot of code words that really mean deregulation and letting the industry regulate itself, and those code words are risk informed, probabilistic risk assessment, common regulatory framework, cost-benefit analysis, new regulatory paradigms.

You know, the theme of this meeting is how can the industry work with the NRC to rewrite safety regulations so that this new plant, new generation of plants can come on line, appear to be safe, get public support, and be economic. And we're not supportive of those kinds of deregulatory efforts.

I'm always very concerned when I hear about merchant plants as well, because we've seen what

has happened, what is happening with merchant plants, for instance, the natural gas plants.

I live in rural Virginia. We're now about to get our third natural gas merchant plant, which is coming in under the Clean Air Act because of a loophole.

We know that there are thousands and thousands of megawatts of merchant plants planned, and there are a lot of questions about the experience of the operators and their financial viability, and I think that it will be of grave concern to the public that there will be merchant nuclear plants.

And I guess lastly, I'll just briefly mention the democratic process because I am a great believer in democracy, and I don't see the process that's been described as having any room for public participation because I don't really believe that the industry thinks that the public supports nuclear power, even if we quote polls.

And so, you know, it's damaging to our democracy when we take away the public's right to engage in discussions about siting and licensing, and we need to have as much public participation as possible.

CHAIRMAN KRESS: Do you have a suggestion

on how that could be done?

MS. HAUTER: Well, I think that these meetings, a meeting like this, if it's held on a work day and the content is incomprehensible to most of the public, that the public is not -- you know, you have to go out of your way to get the public to participate, and I think there should be hearings around the country, and that there should be much more of an outreach effort to engage the public.

Because just referring to Mr. Power's comment about, well, it's the government's policy to support nuclear power, our government is made up of -- you know, it's a democratic government, and it's what the people support, and so, you know, the people should be involved in making these decisions as much as possible.

And I see people shaking their heads. So I think that's the fundamental problem.

DR. POWERS: Just to correct you, it's a federal government.

MS. HAUTER: Yeah.

DR. POWERS: I mean it's a federal. It's not a democratic republic.

CHAIRMAN KRESS: Questions, comments?

DR. WALLIS: Well, we have, I think,

several times in this Committee mentioned that public meetings should involve the public, and we are concerned that they tend to involve people who have some particular interest, which is not perhaps representative of the public, and we've struggled with how to do that.

Whether, in fact, the NRC should somehow -- how do you get public input? How do you get sort of informed technical people who are not part of the nuclear empire, whatever you want to call it, to go there and actually give their attention to it?

I don't know, but we have talked it a fair amount, I think.

CHAIRMAN KRESS: In fact, I think the ACRS considers itself as a public -- taking care of public interests in this whole institution actually. That's the way we view ourselves. So we want to do it in a responsible, technically defensible way.

And you know, if this is a technical issue, it's not always possible to resolve it without using technical jargon or technical arguments. I mean, it is a technical issue.

MS. HAUTER: Yeah, and can I just answer that? I don't think that it's not a technical issue. I think if you want public participation, you hold

meetings where the public can come to them.

I mean, you know, you hold meetings during the time that the public is available. Most people aren't going to take off from work, and probably they can't come, you know, to a two-day meeting, not that you shouldn't have two-day meetings, but you could plan special meetings in different locations that the public could get to.

DR. POWERS: I think in fairness it's important to understand that this particular Committee meeting was done to educate us. I mean, it wasn't really intended to be a public, though we invite the public to participate, and sometimes we actually get some participation. But this was for educating us.

DR. WALLIS: This meeting is actually being recorded, too. So the transcript is available on the Internet. Anybody who wants to who has the access to the Internet.

CHAIRMAN KRESS: Well, I think --

DR. TODREAS: Could I ask --

CHAIRMAN KRESS: Yes, you may ask.

DR. TODREAS: -- a question?

I wanted to just drag out a little bit more on this. This terminology being used here, "risk based," my whole image of this is that's an approach

to try to get everybody to focus on the biggest issues, the biggest regulatory issues associated with plants, the biggest potential hazards associated with nuclear power.

So my whole perception was that that was a move in the right direction relative to putting people's attention on the key things, and what I gather from your reaction is that whole thrust not only misses you, but actually raises suspicions.

So what is the right -- well, first, I mean, do you have any sense as to why or the positive effect that's trying to be accomplished by this thrust, and do you have better words or is there a better way we should project this?

MS. HAUTER: Well, I think risk based analysis had its roots in the late '70s and especially then after the Reagan administration, and it was part of the deregulatory effort. It was to make regulation cheaper and less costly for industry. So I'm going on the roots of where risk based analysis comes from.

So it's not the words that I'm objecting to. It's the idea that agencies are not going to regulate, but that we're going to set up this regime where you're looking at, you know, what is supposed to be the largest risks.

And I think that what it ends up doing is making it appear as if there are fewer risks and, you know, that it's been basically a way to deregulate and make the regulatory regime cheaper.

DR. TODREAS: Yeah, past political practice.

MR. BARRETT: Can I address that? I'd like to say a word about that.

I think that the experience of the NRC with regard to risk based or risk informed regulation may not be the same as what you've experienced in other regulatory agencies. We got into risk informed regulation or risk based regulation in that time frame, in the late '70s, throughout the '80s, and up to today.

And I would say that in the '80s, following the Three Mile Island accident, for instance, it would be possible to list a number of very, very important new requirements that were placed on the regulated industry as a result of our risk analyses.

And so I don't know that for this particular agency it's fair to say that risk informed or risk based regulation has been a deregulatory trend, and I would have to second what Neil said. I

think that when we see the proposals from the industry to take a risk informed look at our regulations for these new types of reactors, we know that there are some of our regulations that are specific to water reactors, and really it would be just wasteful of resources to try to apply them to these new types of reactors.

And we also know that there are challenges to these new types of reactors, such as the fuel, which we've never faced before for a reactor, trying to think of the fuel as part of the licensing process that we're going to have to address.

And so we feel that we need a systematic and technical way that we can lay all of these issues out on a level playing field and say which ones are important and which ones are less important, which ones do we concentrate our resources on.

So our general tendency is to welcome a risk informed approach and to go forward to use that risk informed approach to come up with an optimum approach though.

MR. SIEBER: Maybe I could add to that a little bit. My impression, having once worked in the industry, was that risk based approaches cost us money. One thing that was identified through the

reactor safety study was event fee, which intersystem LOCAs. We had to change our plant for that. IPEs generated design changes for us, and that improved safety.

And I think that risk based approaches go in two directions. You may find when you apply this technique to a plant that you have to modify the plant, modify the way you operate the plant to make the plant as safe as you can.

And, on the other hand, there are things that are in the regulations that are in the plant that when you study them have no risk basis at all and probably represent a cost burden to the licensee for no safety gain.

So I think it goes both ways, and that's the way I perceive what has gone on in applying risk based techniques in the industry over the last 50 years or so.

DR. WALLIS: I see risk based regulation as being or risk informed as being a way of being honest with the public. I mean, the whole idea of regulation is to hold the public risk to some acceptable level, which is acceptable to the public, not something that's acceptable with an agency.

And that communication has to be there on

the basis of what risks are you exposed to and what risks will you tolerate.

So it has to be in the language of risk, and it has to be measured in some way. It can't be vague and waffley. So it seems to me that measures of risk and explaining how we make those measures of risk and how we interpret them and how we decide presumably by some political process about what risk is acceptable is the honest way to do business rather than talking about a lot of technology and loss of coolant accidents and design based accidents and all of these kinds of things, which are technical things.

The common language really ought to be language of risk. So I don't quite see why there's a problem with doing it that way.

MR. LYMAN: Can I just share my impression?

I think the concern the public has is that industry is only interested in risk informed regulation when it perceives that the existing regulations are too conservative, and then making the changes would only go in one direction.

And one good example is the attempt to risk inform the 50.46, which is the combustible gas control regulations is something industry sought

because they wanted to get rid of a whole lot of systems like hydrogen recombiners and hydrogen monitoring that they didn't want.

But when it turned out that there may have been a couple of aspects, for instance, having a back-up power supply for hydrogen igniters in the case of the station blackout in ice condenser plants, that would have introduced -- that was a risk measure that would, by the same token, have to lead to increased requirements, and so then the proposal from NEI was we want selected implementation, which is we can choose whichever we want and forget about the others.

So that gives the impression that they are really only interested in those that reduce cost and burden.

If it's applied systematically, then I agree with you. But then the issue is brought up of how accurate are the risk assessments to begin with.

CHAIRMAN KRESS: That's why NRC's job is difficult. They're there to make those judgments, I think, and to help make them, and I, for one, think they are very diligent about that sort of thing.

DR. WALLIS: Well, part of the problem may be that NRC is perhaps set up, and maybe it has to be by law, to respond to industry, and if industry does

only ask the things which appear to benefit them, then that may be not a very good system. Maybe that's the way -- I'm a bit concerned about that, that the NRC is responding to things.

Well, maybe it has to respond to other forces or maybe your influence, too. That's another way.

CHAIRMAN KRESS: It does have to respond to petitions. That should be the other route.

MR. SIEBER: Well, it's responding now with the development of performance indicators. It's responding to industry trends and plant trends. It responds to its own inspection program. So that actually goes both ways, too.

DR. APOSTOLAKIS: What's wrong with the industry being interested in cutting costs, Mr. Lyman? It's the job of the agency to make sure that they don't do anything that creates undue public health risk, but the fact that industry is interested in reducing the operating cost, I mean, that's not a crime.

I mean everybody has an agenda.

MR. LYMAN: Sure.

DR. APOSTOLAKIS: It's the agency's job to make sure, you know, that the requests that are

granted are really legitimate, and they don't really threaten anything.

And the other thing is I'm always, you know, amazed, not amazed, but maybe puzzled that we always talk about public interest groups, public interest groups. What's wrong with considering the Nuclear Regulatory Commission as the number one public interest group when it comes to nuclear affairs?

Now, you have five Commissioners that have been appointed by the Senate, I mean the President with the approval of the Senate. You know, every year, you know, we have a new one, and they represent different parties.

Then you have the staff, professional people. Aren't they the number one protectors?

I don't hear anybody giving them enough credit. So we have to go out and have evening sessions to meet with the public? The public will get very bored when we get into technical matters, and this Committee is supposed to advise the Commission on technical matters. Why? Because the Commission is a group of political appointees. They're not expected to have the technical expertise that's required. They represent the people.

Don't they represent the people? I'm

confused.

MS. HAUTER: The problem is in our political system, the industry is able to influence Congress, the appropriations process, the executive branch of government through campaign contributions, through lobbying, through a revolving door, and so that type of influence -- the NRC has to be responsive to industry in a way that we believe is not always representing the public interest.

And in a democracy you have tensions between different constituencies, and that's what I think we're discussing here.

MR. SIEBER: But if public opinion is as you say, and I've heard the same stories you did on the recent California polls, the politicians, I think, would respond on the side of where the votes are going to come from, hopefully, and that should be a check and balance on the whole system, which is what I think happens.

MR. BARRETT: I'd like to change the subject a little bit because I want to get to this question about public participation. That's an item that's always challenged this agency, and over the past four or five years we've made a concerted effort to try to improve our performance in that area.

We have tried to have meetings that do make it easier for people to participate at least in terms of trying to knock down the amount of technical jargon, trying to have facilitators who can make sure that everybody is up to speed on what's going on.

But it's still an area that's a challenge for us, and I can tell you we're going to have this workshop in July. It's two days, and it's during the work week, but we will try very hard to make sure that it's a discussion that's open to everyone because at that session we are going to be talking more about how we make decisions and this whole question of risk informed.

But I think the issue of how we get out and make the process even more accessible is something that I think we need to think more about.

CHAIRMAN KRESS: Well, with that note, I think I'm about ready to declare this Subcommittee meeting over with, unless someone has some burning statements.

DR. APOSTOLAKIS: Did you give the public an opportunity to --

CHAIRMAN KRESS: Well, I'll tell you what. I would -- you know, I don't want to put anybody on the spot, but we do have ex-Commissioner Rogers here,

and I would love to hear any words he would like to give us, any words of wisdom and thoughts on the whole meeting.

MR. ROGERS: Well, thank you very much.

There's a lot of things I could say, but I think one of the things that I really would like to say in response to this criticism of risk as a basis for anything, that I've been very enthusiastic about the use of risk analysis by everybody, and the reason is that it is a systematic way of looking at the whole system, not piece by piece, isolated pieces, but at the whole system.

And that's one of the biggest problems in any large, complex, technical operation, which normally gets broken down into individual management pieces -- manageable pieces that can be dealt with, and then they're all assembled, and people say, "Now it's all done. It's fine."

And yet you know that when you put them together, you've got a system that has new features, new ways of expressing itself that you hadn't seen before, and that risk analysis, probabilistic risk analysis is a disciplined approach, a technically disciplined approach to looking at the interactions of all the different parts of a complex system, how they

influence the behavior of the whole thing, and each other.

And what the bottom line number is that comes out of that may not even be that important, but the process of looking at the entire system of how the parts interact with each other and using probabilistic analysis to quantify this process and begin to allow you to pinpoint where the really serious aspects of the system are from a safety point of view is an enormous advance in the protection of public health and safety.

It is not a dodge. It is not a subterfuge to avoid doing the right thing. It is a powerful technical analysis that has not yet come totally to maturity. There are things that we don't know how to include in it. We really don't know how to include human performance in it very well, and we know when al is said and done, many times that is the controlling factor.

But nevertheless, I think it is really a shame to consider risk analysis as simply some kind of a political tool. It is a technically sound discipline that is maturing. It is not totally mature, but it is maturing and has already revealed many, many important issues in nuclear power plants

that were somewhat I won't say undiscovered, but not thought to be very important.

So that, in fact, it does cut both ways, that there are aspects of what we have put in place as regulations that were done early on in the history of the business because we didn't know any better. So we thought, well, that's at least some way of dealing with this problem.

And as time has gone on and we've been able to learn more and more about the total system and risk analysis, the discipline of risk analysis has been brought to bear on the safety of a total nuclear plant. Enormous strides have been made in understanding their behavior.

And I think that the much improved performance of nuclear power plants not only in the United States, but throughout the world is, in part, a result of the application of risk analysis to being able to pinpoint where the weaknesses are and correct them.

So I really hope that you could take away from this meeting at least a sense that this is a technical tool that, in fact, has great power and can produce and has produced significant improvements in plant safety not only here, but throughout the world.

CHAIRMAN KRESS: George, you may have the last word.

DR. APOSTOLAKIS: This reminds me of a debate we had last week as the symposium that John Garrick hosted under the auspices of the Society for Risk Analysis, and I objected then, and I will object now.

It seems to me that it is a miscommunication to talk about risk analysis in general because I understand your complaint about the '80s, risk analysis being used as a political tool, which to a large extent it was.

Risk analysis as used by this agency is not the same risk analysis as used by EPA or chemical oriented kinds of analysis. We're dealing here with a very complex system.

I think the other federal agency that comes close is NASA with the international space station, and so on, very complex, technical systems, and I really think it's miscommunication to call what we do risk analysis and then call what the EPA does risk analysis.

That's why we're using PSA, probabilistic safety assessment. I think what the Commissioner referred to is this systematic approach to a very

complex, technical system that really brings out the weaknesses and so on.

And I think in the chemical world the use of risk analysis is different, although the philosophical approach might be the same. The actual tools for implementing it are different, and a lot of the criticism regarding risk analysis from public interest groups really has in mind the EPA, and generalizing, I think, is not, in my view, appropriate because there are a lot of technical benefits from the probabilistic safety assessment we're doing here.

Unfortunately we have to use jargon and so on, but anyway, I really think risk analysis is too broad a term. It doesn't really cover what we are doing.

CHAIRMAN KRESS: Wonderful. Well, I would like to thank all of the participants in this two-day meeting. I'd like to especially thank this panel who I think have done a very good job.

And with that, I'm going to declare this Subcommittee adjourned.

(Whereupon, at 5:49 p.m., the meeting in the above-entitled matter was concluded.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: ACRS Subcommittee Meeting

Docket Number: (Not Applicable)

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were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

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